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HEARING
ON
NATIONAL DEFENSE AUTHORIZATION ACT
FOR FISCAL YEAR 2014
AND
OVERSIGHT OF PREVIOUSLY AUTHORIZED
PROGRAMS
BEFORE THE
COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES
ONE HUNDRED THIRTEENTH CONGRESS
FIRST SESSION
SUBCOMMITTEE ON INTELLIGENCE, EMERGING
THREATS AND CAPABILITIES HEARING
ON
**BUDGET REQUEST FOR DEPARTMENT
OF DEFENSE (DOD) SCIENCE AND
TECHNOLOGY PROGRAMS**

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APRIL 16, 2013



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AND CAPABILITIES

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FISCAL YEAR 2014 NATIONAL DEFENSE AUTHORIZATION BUDGET REQUEST FOR DEPARTMENT OF DEFENSE (DOD) SCIENCE AND TECHNOLOGY PROGRAMS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND
CAPABILITIES,
Washington, DC, Tuesday, April 16, 2013.

The subcommittee met, pursuant to call, at 3:34 p.m., in room 2118, Rayburn House Office Building, Hon. Mac Thornberry (chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. MAC THORNBERRY, A REPRESENTATIVE FROM TEXAS, CHAIRMAN, SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND CAPABILITIES

Mr. THORNBERRY. Let me call the subcommittee hearing to order, and let me welcome the distinguished ranking member and our witnesses and guests to this subcommittee hearing on DOD's [Department of Defense] science and technology programs.

I don't think any of us need to be convinced that the money we spend on science and technology is the basis for our country's future security. I was pleased, in the President's budget, that if you take these accounts together, at least they are basically flat, and not going down. I guess that is looking for some good news. But, of course, it is not just how much money you spend, it is how you spend it. And those are some of the issues that we want to get into with our distinguished group of panelists.

So without going any further, I am happy to yield to the gentleman from Rhode Island, Mr. Langevin, for any comments he would like to make.

STATEMENT OF HON. JAMES R. LANGEVIN, A REPRESENTATIVE FROM RHODE ISLAND, RANKING MEMBER, SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND CAPABILITIES

Mr. LANGEVIN. Well, thank you, Mr. Chairman.

And I really do want to thank all of our witnesses for joining us today. All of you oversee a portfolio of issues that I have particular interest in. And obviously, defense research is an area of great importance to all of us, and I know that we can all appreciate the benefit of your testimony today.

The health and vibrancy of our defense science and technology enterprise is critical not just to our national defense, but to our Nation's innovative edge in the world's economy. And I am pleased that the President's budget request recognizes this and largely pre-

serves the investments that our warfighters will depend on in future years.

However, I am deeply concerned about the effect sequestration is having on our science and technology investment base. And I know you all touched on this in your prepared testimony, but I would appreciate it if you, in your opening remarks, you could speak to the long-term effects of sequestration, to the research and development being undertaken by the Department, as well as to the longer-term effects on your workforce.

Sequestration is, of course, not occurring in a vacuum. And there are compelling longer-term trends toward ever more sophisticated technology for our warfighters, requiring ever more capable RDT&E [Research, Development, Test, and Evaluation] workforce. I believe that DOD has an important role to play in responding to those trends across the STEM [Science, Technology, Engineering, and Mathematics] spectrum, from the K-12 education efforts that prepare a pipeline of confident operators and maintainers of cutting-edge technology, to the basic research that expands our understanding of disciplines affecting our national security.

Mr. Shaffer, you mentioned these challenges in your testimony, and I certainly look forward to exploring how Congress might assist DOD in addressing those needs. It is imperative that, to preserve the vitality of the workforce.

Similarly, Mr. Shaffer and each of the service representatives, I would be interested in an update on your examination of laboratory facilities and whether action is needed at the congressional level to ensure the vitality of those institutions. I would also appreciate an update on the Rapid Innovation Program.

While I know that this is not the venue for detailed discussion of your entire portfolio, it certainly would come as no surprise to the chairman or to our witnesses that I am particularly interested in hearing your comments on just a few areas.

Dr. Walker, Ms. Miller, and Admiral Klunder, you highlighted particular efforts within the directed energy field that show particular promise, and I would be interested in hearing more from my panel on DOD efforts in that regime. I would also welcome comment, Admiral, on your development of unmanned undersea vehicles, which you and I have had a chance to talk about many times.

And, finally, I recognize you have all highlighted the critically important role that cyber innovation plays in our defense enterprise. And I look forward to hearing more about how the Department's research could result in a stronger national defense.

With that, the DOD/STS [Department of Defense/Science and Technology Strategy] enterprise is crucial to our Nation's national security over the long term, and I look forward to working with the chairman and with all of our witnesses today to make sure that we get it right.

So with that, I thank the chairman for holding this hearing, and I yield back.

Mr. THORNBERRY. I thank the gentleman. And I would also ask unanimous consent that other committee members be allowed to participate in today's hearing after all subcommittee members have had the opportunity to ask questions. Without objection, they will be recognized for 5 minutes after everybody else has had a chance.

Again, let me welcome our distinguished panel of witnesses, Mr. Alan Shaffer, Acting Assistant Secretary of Defense for Research and Engineering; Ms. Mary Miller, Deputy Assistant Secretary of the Army for Research and Technology; Rear Admiral Matthew Klunder, Chief of Naval Research; Dr. David Walker, Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering; and Dr. Arati Prabhakar, Director of the Defense Advanced Research Projects Agency and a distinguished graduate of Texas Tech University. So if you want to know how come she is so smart, it is because of where she got her bachelor of engineering degree, just for the record.

Without objection, all of your written statements will be made part of the record. I would appreciate it if you all could summarize your comments in approximately 5 minutes. And I would be particularly interested in your summary, if you could—in addition to talking about the things Mr. Langevin talked about, kind of where we are with budgets and what its effects are—what the budget effects are on your programs, but also talk about the trends. What do you see as the changes?

I mean, we have this hearing year after year. I would be interested in what is different, what you see is—where the movements are, again, the trends of what we need to keep our eyes on.

And with that, I would turn to you, Mr. Shaffer, for 5 minutes.

STATEMENT OF ALAN SHAFFER, ACTING ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

Mr. SHAFFER. Chairman Thornberry, Ranking Member Langevin, members of the committee, I am proud to be here today to represent the scientists and engineers in the Department of Defense, a group that includes science and technology researchers, systems engineers, and developmental test and evaluation personnel. And I will try to address the questions on the update of the lab facilities, the rapid innovation program, and the trends as we go into the question-and-answer.

Together, the professional scientists and engineers conceive, develop, and mature systems early in the acquisition process. They work with our partners in industry, academia, other Government agencies, and international partners to provide unmatched operational advantage employed by the men and women of our Army, Navy, Air Force, and Marines, as well as allied personnel.

When we look at the capabilities developed and delivered by these people during the wars in Iraq and Afghanistan, I contend the Nation has returned good—has received good return on investment. Each of my other four leaders on this panel can cite capabilities they delivered for the war. I will cite three that came out of the Office of the Assistant Secretary.

We brought forward the mine-resistant ambush-protection vehicles, the persistent threat detection systems and persistent ground surveillance system tethered surveillance systems, and the use of multispectral imagery to detect explosives remotely. These three alone greatly enhance the safety of our deployed force. We met the demands of an armed force at war.

As we wind down in Afghanistan, the national security and budget environments are changing. We are heading into uncer-

tainty. The fiscal year 2014 budget request for S&T [Science and Technology] is \$12 billion, a nominal increase from the \$11.9 billion requested in 2013. However, it is not possible to discuss the 2013 and 2014 budgets without addressing the impact of the sequester, which takes about 9 percent from each of our programs and each of our program lines.

This reduction will result in delay or termination of efforts. We will reduce awards. For instance, we will reduce university grants this year by roughly \$200 million and potentially reduce the number of new smart scholarships in fiscal year 2013 to zero.

Because of the way the sequester was implemented, we will be very limited in hiring new scientists this year. Each of these actions will have a negative long-term impact on the Department and national security. While there are budgetary pressures, there are new challenges.

DOD leadership has made a strategic choice to protect S&T where possible. We did this to provide options for the future, as well as meet new challenges that have technological dimensions. These challenges include instability in nations like Syria, a state with weapons of mass destruction that could fall out of state control; North Korean nuclear weapons coupled with a means to deliver them; the emergence of very sophisticated anti-access/area denial capabilities in a number of nations; the emergence of sophisticated cyber exploitation and attack; and the increase in sophistication of advanced electronic attack capabilities of some of our potential adversaries.

The challenge is clear, as is the guidance from our leadership. The President and the Secretary of Defense depend on defense research and engineering to make key contributions to the defense of our nation. S&T should do three things for national security. First, mitigate new and emerging capabilities that could degrade U.S. security. Second, affordably enable new or extended capabilities in existing military platforms and systems. And, third, develop technology surprise through science and engineering applications to military problems.

The Department's S&T programs are focused on meeting these goals. We have emphasized cross-cutting programs. For mitigation of emerging threats, we have focused S&T programs on electronic warfare, counter space, cyber, and countering weapons of mass destruction. For affordability, we have an initiative called engineering-resilient systems. And in developing technology surprise, we have initiatives in autonomy, large data, or data to decisions, and human systems.

While there is very good work ongoing in each of these areas, these areas focus the DOD on some of the emerging things—emerging technology areas. In summary, the Department's research and engineering program is faced with the same challenges as the rest of the DOD, but our people are performing. We appreciate the support of Congress to let us continue to meet the national security needs of the Department and the Nation.

Thank you.

[The prepared statement of Mr. Shaffer can be found in the Appendix on page 29.]

STATEMENT OF MARY MILLER, DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND ENGINEERING

Ms. MILLER. Chairman Thornberry, Ranking Member Langevin, and distinguished members of the subcommittee, thank you for the opportunity to discuss the Army's science and technology program for fiscal year 2014. I have submitted a written statement and ask that it be included in the record.

Over the course of these past 12 years of war, the world has seen firsthand the value and impact that technology brings to the battlefield and how capabilities enabled by technology are critical to our soldiers and their success. The Army depends on its S&T enterprise to research, develop, and demonstrate high-payoff technology solutions for hard problems faced by soldiers in ever-changing, complex environments.

Uncertainty and complexity are at the heart of the Army's challenges. The Army of the future requires solutions that are both affordable and versatile and relies on the S&T community's contributions to ensure that they remain the most capable in the world. We are grateful to the members of this committee for your sustained support of our programs.

The overarching vision for Army S&T is to foster innovation, maturation, and demonstration of technology that provides increased capabilities for our warfighters. Our mission includes a transition of both the understanding and knowledge acquired while developing technology solutions, as well as the materiel itself.

While the very nature of S&T puts our focus clearly on providing capabilities for the future, we continue to exploit opportunities to transition solutions to the current force. Any effective Army strategy starts with an understanding of the national military strategy, joint warfighting concepts, and both current and future threat environments. This strategy has expanded our focus from the current fight to the situation at Pacific Rim, a situation where we may well face a more capable enemy in an environment that is much more contested and complex.

Given the current budget environment and prospects of funding in the future, it has become even more important than ever that we clearly understand our current capabilities and what we need to address ever-evolving threats. With that in mind, the Army has initiated a comprehensive strategic modernization strategy to better facilitate informed decisions based on long-term objectives within a resource-constrained environment.

This 30-year look requires us to think beyond the easy answers of just doing what we are doing now but for a bit longer. It forces a new look at what else we might need to do. The world of 2040, 2045 is clearly not going to look like the world today. The threats we face and capabilities needed to address those threats may, in fact, look very different. It is through this type of lens that we will identify key areas in stable investment and those that we will, by necessity, begin to take risk.

In the Army's fiscal year 2014 S&T budget, you see a clear move away from investments in advanced technology development, budget activity three, and advanced component development and prototypes, budget activity four, to comply with the defense planning guidance. This resulted in a number of efforts being slowed while

we reinvested in applied research to facilitate that next generation of capability. In addition, you will note an increase in efforts to assess our vulnerabilities to anticipate threats at both the individual technology level and also our integrated systems levels.

It goes without saying that the underpinning of all Army S&T efforts is a strong research program that builds an agile and adaptive workforce and technology base to be able to respond to future threats. Investments in S&T are a critical hedge in acquiring technological superiority, with revolutionary and paradigm-shifting technologies. This includes the development of the next generation of Army scientists and engineers. Investing wisely in people with innovative ideas is our best hope for new discoveries to enable the Army of the future.

Sequestration impacts not only our ability to maintain this important investment in technology, but also our ability to recruit and retain the scientists and engineering workforce. In a fiscally constrained environment, we will emphasize S&T areas that address truly Army-unique challenges. We will collaborate with our Services, national labs, academia, industry, and partner nations to solve common challenges. As good stewards of the taxpayer dollars, it is critical that we use finite Government resources to maximize development of technologies to meet Army-unique challenges and constraints. It is important that we complement what the private sector is already developing and that we leverage the work being done by our sister Services and allies. Most importantly, our investments must translate into capabilities as we successfully field to the Army of the future.

Thank you, and I look forward to your questions.

[The prepared statement of Ms. Miller can be found in the Appendix on page 61.]

**STATEMENT OF RADM MATTHEW KLUNDER, USN, CHIEF OF
NAVAL RESEARCH, U.S. NAVY**

Admiral KLUNDER. Thank you, Chairman Thornberry and Ranking Member Langevin and our subcommittee members. Thank you.

It is an honor to report on science and technology efforts in the Department of the Navy and discuss how the President's fiscal year 2014 budget request supports the Navy and the Marine Corps. Our objective is to support a Navy and Marine Corps that can operate and prevail in any environment. We work directly with the Secretary of the Navy, the chief of naval operations, and the commandant to strike the right balance between near-term technology innovation and long-term leap-ahead research.

The Office of Naval Research, in partnership with the Marine Corps Warfighting Lab at Quantico, strives to create game-changing capabilities for our sailors and marines, while improving system affordability, communication with the acquisition community, and constructive engagement with all of our stakeholders. We do this with the understanding that anti-access and area denial threats will continue to increase. Cyber war challenges will also only increase and become more complex.

These are not easy tasks and easy problems. We recognize that. And certainly the sequestration has had a dramatic impact. This year alone, we terminated 300 university small grants, and over 50

percent of our future naval capability efforts. But we are up to the task, and we are still making progress.

Furthermore, we are striving to get away from using \$3 million weapons to defeat \$50,000 threats. We must get on the right side of that equation. And I can report that we have weapons in development and being fielded that will allow us to reverse that asymmetrical cost advantage that currently is held by some of our adversaries.

The bottom-line imperative for the Department of the Navy is, we can't just make hugely effective systems anymore. They also need to be extremely affordable.

With your permission, I would like to highlight an effort which has been in the news and highlights recently and a specific approach to that effort, and that is our laser weapon system, LaWS [Laser Weapon System], as we refer to it, part of our solid-state laser maturation effort.

Energy weapons—and specifically directed energy weapons—offer the Navy and Marine Corps game-changing capabilities in terms of speed of light engagement, deep magazines, multimirion functionality, and affordable solutions.

Now, laser weapons are affordable due to the very low engagement costs. Right now, we are projecting under one U.S. dollar. That is what we have seen, which is critical to our current fiscal environment. They are capable of defeating adversary threats, including fast boats, UAVs [Unmanned Aerial Vehicles], other low-cost, widely available weapons.

This LaWS system leverages advancements we discovered and worked with in the commercial technology for use in rugged, robust prototype laser weapon system. It is capable of identifying, illuminating, tracking and lasing enemy surfaces and air threats. And it works. I can offer that we have been thus far 12 for 12 in our prototype testing. We have not failed yet.

If you have seen the news or were able to attend the Sea-Air-Space last week potentially, you may be aware that the Navy is scheduled to install the LaWS system aboard the USS *Ponce* in the Arabian Gulf in early 2014. That harsh and operationally important environment will provide us an ideal opportunity to evaluate long-term system performance. The LaWS has every potential for being an extraordinary success, in terms of fielding an effective and affordable weapons system for our sailors and marines.

We will continue to duplicate this kind of success in our other S&T areas with our innovative research and disruptive thinking. Mr. Langevin, again, you talked about undersea vehicles. That is exactly where we want to go with that, sir. We are also trying to make existing systems more affordable and effective with improved transitions to acquisition programs.

In that area, we start with the effective evolution of current systems. We move to incremental improvements and spiral development of known technologies. And then we go on to discover disruptive technologies that are a gold standard of our Navy and Marine Corps warfighting.

Our research is both exhilarating and unpredictable. We balance a range of complementary, but competing research initiatives by supporting advances in established operational areas, while sus-

taining far-reaching, long-term efforts that may prove disruptive to our traditional operating concepts.

I would be remiss, however, if I did not mention the stellar contribution made by our entire workforce at the Naval Research Laboratory in Anacostia, as well as all the Navy and Marine Corps labs and warfare centers around the country. I certainly always invite everyone in this room to take advantage of that opportunity to go down to NRL [U.S. Naval Research Laboratory] firsthand. The work there is absolutely impressive. The people are much more so.

One of our greatest challenges is to recapitalize NRL and ensure a continuation of their cutting-edge work. I thank the committee for your help in that area and helping us modernize our labs. I certainly want to thank you again for your support—excuse me—and look forward to answering any questions.

Thank you very much.

[The prepared statement of Admiral Klunder can be found in the Appendix on page 87.]

Mr. THORNBERRY. Thank you. And we will, along with you, I think, watch how this deployment of the laser goes, because like Mr. Langevin, I share his enthusiasm for the potential of directed energy of all sorts. And so I appreciate getting something out into the field to see how it really works.

Admiral KLUNDER. Thank you, Chairman.

Mr. THORNBERRY. Dr. Walker.

STATEMENT OF DR. DAVID WALKER, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY AND ENGINEERING, OFFICE OF THE ASSISTANT SECRETARY FOR ACQUISITION

Dr. WALKER. Chairman Thornberry, Ranking Member Langevin, and members of the subcommittee, I am pleased to have the opportunity to provide the testimony on the fiscal year 2014 Air Force science and technology program. This is my first chance to address you since I took over as the Air Force science and technology executive in August of last year.

As the nature and sources of conflict throughout the globe have become more diverse and less predictable, our Nation continues to face a complex set of current and future security challenges, many of which are outlined in the defense strategic guidance issued by the President in January of 2012. This guidance directs a renewed focus on the Asia-Pacific region, as well as continued emphasis on our current conflicts. As Secretary Michael Donley shared his testimony last week, investment in our science and technology base is necessary to ensure the future balance of power, and remains in our favor.

The Air Force fiscal year 2014 budget requests the S&T at about \$2.3 billion, which is a slight increase over our previous year's request. These investments support a robust and balanced foundation of basic research, applied research, and advanced technology development, or provide for demonstrated transition options to support our future warfighting capabilities.

This year's budget request reflects a strong support for S&T from our leadership and this challenging fiscal environment that we find

ourselves. It is a balance across the warfighter's needs, from near-term, rapid-reaction solutions, midterm technology development, and revolutionary far-term capabilities.

The Air Force has matured its S&T planning process a great deal over the past few years, improving our alignments between the science and technology and the capability gaps that are outlined in our Air Force core function master plans. The established S&T planning and governance process ensures that S&T investments are well understood, structured for success, and poised for transition when completed.

This process is the backbone of the Air Force S&T contributions to the larger DOD priorities and strategies and has provided us an opportunity to be the lead for some of the Department's research and strategy planning efforts, in particular in cyber, autonomy, electronic warfare, and in manufacturing technology. I would like to highlight a few of those.

The importance of the dominance in cyberspace to me cannot be overstated as the foundation for the global vigilance, reach, and power. The Air Force has placed a great deal of emphasis on cyber S&T to overcome threats and have provided systems and methods that are affordable and resilient.

The chief scientist at the information directorate at the Air Force Research Laboratory in Rome, New York, has been charged to chair the collaborative joint cyber S&T roadmapping effort for DOD based on the laboratory's history of exceptional cutting-edge research in cyber.

Using the Air Force's Cyber Vision 2025 as a blueprint, we have developed and are executing our Air Force cyber S&T strategy. The pivot of emphasis to the Asia-Pacific region means that missions with the expanded duration, intermittent communication disruptions, and a large array of asset capabilities, as the lead for the cross-service autonomy steering group, and as an active member of the human systems steering group, the Air Force is conducting state-of-the-art research in both human systems and human performance to better enable warfighters to enhance military capabilities, as well as to enable autonomous systems to extend human research providing potentially unlimited persistent capability.

The envisioned security environment of the future will also require military aircraft to operate in highly contested environments. Manipulation of the electromagnetic spectrum can help us negate the integrated air defenses of our adversaries.

As the lead for the Department of Defense's Electronic Warfare Priority Steering Council, the Air Force is facilitating the roadmapping effort for research and revolutionary new technologies and techniques to be effective in the ever-evolving electronic warfare threat, providing the ability to operate in the anti-access, area denied environment.

The Air Force also leads the Department of Defense development and demonstration of technology solutions to decrease manufacturing risks and increase weapons affordability in the aerospace, propulsion, structures, and ISR [Intelligence, Surveillance, and Reconnaissance]. The Nation can build more capability and lean more fighting force by developing a much more efficient and responsive manufacturing and industrial base than we currently have today.

We are exploring strategic issues and opportunities for moving the manufacturing considerations earlier in the design cycle to reduce acquisition costs and risks, to enable streamlined—or seamless life-cycle, value-stream management and integrated industrial base enterprise to identify and react to supply-chain issues.

Our S&T portfolio has emphasized areas of great promise, and we continue to invest in adaptive engine technologies to provide better fuel efficiency and performance. We have emphasized research in hypersonic technology to provide capability to counter adversary anti-access and area denial, to actively engage time-sensitive targets, and to overcome the challenges of distance and time as we shift our focus to the Pacific.

Finally, we have built on our successful flight test of the counter-electronics high-powered microwave advanced missile project, or CHAMP, and continue to develop the direct energy capabilities to defeat our adversaries' electronic systems on the ground.

While there are still uncertainties with sequestration and the impacts are yet to be seen, I believe this budget reflects the promise of the future of warfighting capability and enables technology that will be with us—worth the investment placed in it.

Mr. Chairman, I thank you and the committee again for the opportunity to testify today, and thanks for continued support for the Air Force S&T program.

[The statement of Dr. Walker can be found in the Appendix on page 103.]

STATEMENT OF DR. ARATI PRABHAKAR, DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Dr. PRABHAKAR. Thank you, Mr. Chairman, Mr. Langevin, members of the committee. It is a great pleasure to be here with you today.

DARPA's [Defense Advanced Research Projects Agency] objective is a new generation of technology for national security. Now, actually getting this new set of military capabilities is going to require a lot of work with a lot of different organizations, certainly my colleagues in the Service S&T organizations, but also our universities, companies large and small. Ultimately, it is going to be our warfighters who take the technologies that we deliver to them and implement them and turn them into real military capability.

DARPA's role in all of that is to make the pivotal early investments that change what is possible for the future, the investments that really let us take big steps forward in capability. That is what we have done over our 55-year history, and that is what we are working on for the next generation.

So what can that next generation of military capability look like? That is the question that shapes our portfolio of investments at DARPA, and today it means that we are building a future where our warfighters can use cyber as a tactical tool, fully integrated with the kinetic fight. We are building a new generation of electronic warfare that can leapfrog what others around the world are doing with globally available technology. We are investing in a new generation of position, navigation, and timing technologies so that our people and our platforms don't have to continue to be dan-

gerously reliant on GPS [Global Positioning System] as they are today.

We are investing in new approaches for space in robotics, in advanced platforms, and new weapon systems, and beneath all of these activities, we are building a new technology foundation, as we invest in some of the emerging areas within software and materials and advanced electronics, and now adding to that some of the new technology areas that are emerging from the biological sciences, as well.

So if we are successful in that enterprise, our success really will mean that in the future our future leaders and commanders will have really powerful options, real options to deal with whatever threats our Nation faces in the years to come, and that really is what is going to allow us to advance our nation's strategic interests in a decisive way. That is really what we are striving for.

So—and I am very happy to talk—those are my favorite topics. I would be happy to talk about any of them in greater detail. But I also want to take a minute and talk about what it is going to take for DARPA to be able to deliver on this critical mission. And as you all well know, it takes resources, both funding and people, and with that, a stable, long-term commitment to these long-term objectives.

We have been so fortunate to have that kind of strong support from the leadership in our Department from across Congress. And I especially want to thank this committee for the support that you have provided for our budget over many years and in particular the work that you have been doing to give us flexible hiring authorities.

Last year, you expanded the number of 1101 flexible hiring slots that our agency has. I want you to know that that is absolutely essential to our ability to hire the stellar program managers that we need. They spend about 3 to 5 years at DARPA. We draw from some of the best organizations in the technology community across the country, and we simply couldn't get the people that we need without the kind of authorities that you all have supported so vigorously, so I very much have appreciated that.

Now, the bad news, of course, is that sequestration is undermining what is otherwise this very strong support environment that we live in. Like others in fiscal 2013, we are taking cuts across each of our program elements. It amounts to about 8 percent per program element at DARPA. Our civilian Government employees, all of us will be participating in the Department-wide furlough, as well.

And, you know, just to cut to the chase, for our program managers, what those impacts mean, these are people who have come to DARPA for a short time to do something big. And when they see these program delays, when they are told under furlough that, you know, you can't work 1 day a week for that furlough period, those are enormous negatives for these driven individuals.

So obviously, this one-time hit through sequestration has real consequences. It does not destroy—you know, it is not a death blow to our ability to accomplish our long-term mission. But it is corrosive, and if it continues, it will—this kind of action does, in fact, erode our fundamental ability to perform our mission.

Let me just end on a personal note. I returned to DARPA after 19 years last summer, after spending a number of years in other positions, primarily working in the commercial sector. I came because of DARPA's off-scale impact, and I came because I knew that we needed to invent this new generation of technologies to reinvent, once again, how we keep our country secure.

And I came for the privilege of leading this unique organization, where despite all of the challenges that we have, our people are still running to work every morning with their hair on fire, because they know they are part of a mission that really matters. I really want to thank this committee for your focus on these issues and for the longstanding support that allows us to do this work.

Thank you. And I am very happy to answer questions with my colleagues.

[The prepared statement of Dr. Prabhakar can be found in the Appendix on page 132.]

Mr. THORNBERRY. Thank you. I appreciate all the comments all of you have made.

I apologize, too. I am going to have to leave in a few minutes. I have been drafted to go help moderate a cybersecurity classified briefing for all House members, so I am going to submit my questions in writing to you and yield to other members.

And I will yield the first 5 minutes to Mr. Gibson.

Mr. GIBSON. Well, thanks, Chairman. And I appreciate the panelists being here today.

My questions have to do with nanotechnology, and I would like to hear, first, from our director from DARPA about where you are going, in terms of future for nanotechnology, and then I would love to hear from Mr. Shaffer, too, in terms of how you are managing this from the vantage point of the DOD, with all the disparate and exciting projects that are under way in every regard.

Dr. PRABHAKAR. Thank you for the question. You know, nanotechnology investments over the last decade or two have given us a set of tools that we find we can now apply in a host of different areas. So just simple examples. One of the areas where we now have the ability to make structures that are very fine, very regular, very controllable, some of those applications tie back to what I was saying about position, navigation, and timing.

So we have been able to make very sophisticated IMUs [inertial measurement units], navigation units, on a small chip. We have been able to use that nanotechnology—fabrication technology, in that case—to shrink devices that are vast and consume a lot of power to a size that allows them to be embedded in much smaller platforms and really gives us the ability to maintain position information over a much longer time, and that is just one of a very wide range of new capabilities that come as we—you know, as nationally we have developed our muscle in nanotech.

Mr. GIBSON. I appreciate that. And as a former infantryman, I think there is tremendous possibility here in terms of it being lighter, more durable, more effective, so I have been following with keen interest the research that is coming out of your organization, very encouraged.

Mr. SHAFFER. So I am going to try to keep this from being a bureaucratic answer, because I hate bureaucratic answers. My job is

to try to get the program aligned across all the Department's components. To that end, we have set up a series of—I would call them committees, but they are more than that. You heard some of our folks talk about them. SES members from each of our components with a major investment in an area like materials come together and plan out their material program, which includes nanotechnology.

These are co-led by our folks, my folks in OSD [Office of the Secretary of Defense] and the Services, typically the Services. The material sciences is led by Dr. Julie—and I am going to butcher her name—Christodoulou from the Navy, but she gets together with the SES-level folks in charge of materials and nanoscience and plans out and integrates their program, so we try to drive down duplication, but we are also going after those things that will matter.

As a former airman who spent 5 years on the ground with the Army, I absolutely will tell you, I wanted lighter equipment when I was out there. That is one of the promises of nanotechnology. Higher energy density is a promise of nanotechnology. Small lightweight machines—and there are miracles happening every day at DARPA and in our Services focused on specific technologies. My job is to try to get the programs knitted together. And I think we are doing okay with that.

Services, anything you would like to say?

Admiral KLUNDER. I can only add, Al, sir, that the commandant of the Marine Corps, lightening the load is absolutely one of his priorities from the infantry standpoint, the Marine standpoint. And my colleagues, DARPA and the Services, we have seen great collaboration there. An area of specific interest from our standpoint was on our electronic EW [Electronic Warfare] sensors. As the nanotechnology has shrunk considerably, we have now had wide bandgap spectrum apertures that give us much smaller size. It can be on a Jeep, it can be on an infantryman, and it can be on a ship. It gives us that ability not only a communication aspect, but, again, clearly on a defensive or offensive aspect, so we are right behind you, sir, on that.

Mr. GIBSON. Well, I appreciate the commentary. And the reason why I am asking about the management of it is, is as exciting as this field is, you know, it—the challenge is really sort of harnessing the synergy across the Services. It is why I was curious—you know, Senator Gillibrand and I, going back a couple years ago, we raised the possibility of perhaps a clearinghouse for this, the possibility of an FFRDC [Federally Funded Research and Development Center], and so—you know, I am just reengaging again what that possibility, certainly open to hearing all sides on this. But in the interests of time, looks like I am about out here, but this is a topic I would like to continue to dialogue about.

Mr. GIBSON. Thank you. And I yield back, Mr. Chairman. Thank you. And I thank the ranking member, as well.

Mr. THORNBERRY. Thank you.

Mr. Langevin.

Mr. LANGEVIN. Thank you, Mr. Chairman.

So I had several questions that I would like to get to, but let me start off with this. Defense Secretary Hagel told the House Appropriations Subcommittee on Defense this morning that there is a

major reprogramming request on the way. And obviously, while we have to certainly cover the costs incurred by operations overseas and maintain our faith with our troops, I am very concerned that the S&T investments that we are depending on to enable our future force could pay a disproportionate cost under such a request.

And while the weapons procurement can run into the hundreds of millions per system, \$100 million in the S&T world could mean dozens of promising programs that enable future capabilities. So could you describe to the subcommittee, to the extent that you are able, at least, what the impacts of the S&T—what would be the impacts to the S&T enterprise of this reprogramming, I should say?

Mr. SHAFFER. Sir, let me take that one on first from a Department level. Obviously, we can't talk about the details of the reprogramming going on. What I can tell you is that we are at a very fortunate time now. I have worked for both Dr. Carter directly, the deputy secretary, and Mr. Kendall, and they both very much understand the value and the long-term commitment to science and technology.

So as of right now, I don't think that there is a wholesale rush to trade in science and technology for operations and maintenance. There will be some pressure. We have a situation right now where, for a number of reasons, we have underfunded the troops that we are—that are deployed supporting our Nation. But right now, we are very fortunate with the leadership in the Pentagon, between Mr. Kendall, the under secretary of acquisition, technology, logistics, and Deputy Secretary Carter, that they understand that science and technology needs a long-term stable base and were—I will tell you that I am using that too every chance I can get.

Mr. LANGEVIN. Anybody else?

Ms. MILLER. Sir, speaking for the Army, I can echo what Mr. Shaffer said. The Army leadership understands the value and importance of the science and technology investments and are protecting it this year.

Admiral KLUNDER. I can offer, we are very fortunate OSD is the lead, that as it came down to the Department of the Navy, the Secretary of the Navy, the commandant, and the chief of naval operations, that is exactly, sir, how we were able to put that LaWS system out on the USS *Ponce*, because of that kind of commitment, and we are very fortunate, indeed, that we have got the leadership that supports innovation in science and technology.

Dr. WALKER. And the Air Force leadership is exactly the same. They have been trying to protect science and technology through this process. As we go through the remainder of fiscal year 2013, we will see, as pressures continue to build, but so far we have had good support.

Mr. LANGEVIN. Let me turn my—I still have time—so in the area—one of my favorite topics, cyber, obviously, in the area of interest for myself and the chairman, where do you see the research and development in the cyber arena heading in the near and mid-term? And are we adequately postured to address those challenges in the S&T community?

Dr. PRABHAKAR. I will be happy to start, and then others I am sure will have others to add.

Our focus at DARPA in cyber, very similar to other things that we do. You know, ours is not an operational responsibility. Our question is, how do we shift the trajectory we are on to one that is more advantageous to us in the future?

And I would characterize the trajectory that we are on today in terms of cybersecurity as one in which we patch and pray, we see an attack, we patch it up, and we hope that is enough, and then we wait for the next attack to come. That is pretty much all we really have to go with.

It is very human-intensive. And we are scrambling, as you see to hire quickly enough the people that can keep up with the threat as it continues to accelerate.

We are looking for a fundamentally different way to think first about cybersecurity on the defense side, but then also how to think about cyber offense in a new way. The core idea in both cases is to automate and get beyond needing to scale manually to deal with the challenges that we have.

In the case of cybersecurity, we have a series of programs that are trying to find more fundamental ways to build inherently secure systems or to interrogate legacy systems and understand what level of security they actually have. In terms of cyber offense, we aim to create a capability that allows cyber offense to become fully integrated with the way our warfighters fight in kinetic terms, so that instead of being something off to the side, it is really part of how an engagement takes place the way electronic warfare, if you like, is really fully integrated with the kinetic fight today.

So, you know, that is—those are the visions that we have about where cyber could be that I think would put our country in a much more advantageous position, and that is the focus of our investments today.

Mr. LANGEVIN. Thank you. Well, I have other questions, but my time is expired. I will yield back.

Mr. THORNBERRY. Mrs. Hartzler.

Mrs. HARTZLER. Thank you, Mr. Chairman.

Ms. Miller, I—in your testimony, I—you talk a little bit about continued developments in finding lighter, more capable armor solutions. So could you describe the Army's effort with silicon nitride?

Ms. MILLER. Yes, ma'am. Currently, at the Tank Automotive Research Development and Engineering Center, we are investigating armor solutions for tactical vehicles. We have a tactical vehicle armor program. We are currently looking at six different vendors, two of which are Government, four of which are actually commercial. They are competing their armor solutions. We are making them comply to the long-term armor strategy criteria.

We will down-select to two vendors that will then go forward for maturation—further maturation of the armor design in the end of fiscal year—this fourth quarter of fiscal year 2013. The silicon nitride is one of those armor solutions that is being pursued.

Mrs. HARTZLER. Great. Is it a potential solution over steel and some of the other metals used today, are you seeing so far you think might have potential?

Ms. MILLER. Right now, it is not meeting the criteria of the long-term armor strategy, but they have been—the folks that are doing the silicon nitride work have been modifying their formulation of

the armor, and then we are retesting. We expect more samples to come in and to retest against our criteria.

Mrs. HARTZLER. Yes, that is, I think, very, very exciting. The tactical vehicle armor development program, you know, will not only benefit the warfighter by reducing the armor weight used in tactical vehicle platforms to increase survivability, as well as mobility. Do you believe that the current funding for the TVAD [Tactical Vehicle Armor Development] program is adequate to meet the needs of the warfighter?

Ms. MILLER. Yes, ma'am. I believe the funding is adequate. We have armor development that exists at the Army Research Lab for fundamental armor design, modeling and simulation. We do maturation at the Tank Automotive Research and Development Engineering Center, TARDEC [Tank Automotive Research, Development and Engineering Center], and we do believe we are adequately funded.

Mrs. HARTZLER. Okay. I think it has a lot of exciting potential there.

Admiral Klunder, in your comments, you talked about the new laser systems, the 12 for 12 testing. I thought that was very, very exciting. I haven't read up on it as much as perhaps some of the others, but can you explain a little bit more about how that would work?

Admiral KLUNDER. Yes, I can. Thank you. The significance that we always look at is in terms of the risk of the development, and we started out in a very dry desert environment. But we are in the Navy and the Marine Corps, and we are out in the ocean. We are out on the high seas. And that is a very difficult maritime environment.

And why do I bring this up? Our first phase was in the desert. We then moved out to the Pacific Ocean off of the California coast. And then our final test was recently done on USS *Dewey*, and that is a just regular destroyer down at the pier in San Diego. And why I bring that up is, if we didn't functionally change the ship, if we hadn't put this prototype laser system on the USS *Dewey*—and, again, off the California coast, is a very successful, went three for three shooting down UAVs.

The reason why we are now excited about moving it out to the Fifth Fleet area of operations in the Arabian Gulf area is, again, it is a very harsh environment, very dynamic environment. We are obligated to our Nation to protect our high seas for the commerce of our country, our national security, and we think that is a very good place to put this out there and let some sailors look at it, test it, see if there is any lessons we learn, and then if we do, we will bring them back and roll them into our follow-on upgraded systems, if that helps.

Mrs. HARTZLER. Yes, it is very exciting. And appreciate all that you do there for our national defense. Thank you.

I yield back.

Mr. KLINE. [Presiding.] Mrs. Davis.

Mrs. DAVIS. Thank you. And I appreciate all of you being here with us today.

Dr. Prabhakar, you mentioned the impact of furloughs, and certainly our civilian workforce, Federal civilian workforce, which in

many ways I think has been maligned of late, but I wonder if you spoke about the fact that a number of people may come in from the private sector and they are with us for a relatively short period of time, and the other issue really is one of just patience. You need a timeframe when you are working with research and development.

Are there some areas particularly that you are worried that that will impact more than others? Is it—does it relate to the warfighter? What does it relate to that we should, you know, anticipate and be some concerned about?

Dr. PRABHAKAR. Specifically, from the furlough impact?

Mrs. DAVIS. Yes.

Dr. PRABHAKAR. Right. So the one-time financial hit from sequestration, because it is across the board, really affects each of our programs pretty broadly, so across DARPA, about 100 of our programs were affected. The net effect really is, you know, at the specific contract level, there are universities and companies large and small that are finding out that a contract they thought was about to get signed has gotten pushed off or has now gone away. There are efforts that are under way where, you know, the funding isn't going to show up as predicted.

We have worked very, very hard to minimize the impact as much as we can, but at that—you know, at the level that we are dealing with in fiscal 2013, we do start to see real consequences.

One example is Plan X, which is our cyber offense research program. That is a program that is taking a pretty significant hit in fiscal 2013. Because it is a relatively new program—we were just getting it under way—there we chose to take a delay of about 4 or 5 months, rather than having to stop a bunch of things that were already fully ramped up and under way in other programs.

So the consequence on that area will just—it will simply translate to later, you know—essentially, the schedule for starting to deliver some of those capabilities to our service partners who have expressed a lot of interest, simply keeps pushing to the right.

I want to mention one other thing. You know, the other place that we are seeing a lot of impact from furloughs and sequestration is the fact that we work so closely with our service partners. Our contracting times are pushing out, because we are relying on contracting capability in the Services.

Mrs. DAVIS. Yes, I was going to ask—actually ask, not just with the Services, but also across the board, and, you know, the whole-of-government approach, because my guess is that they also will be impacted. And whether it is working with homeland security or commerce or ag [Department of Agriculture], whatever that may be, where you interface are—is that another area that you anticipate that there is going to be a considerable impact? Or, you know, is it—probably won't have as great a concern as perhaps working within the Services, in terms of the job that you all do?

Mr. SHAFFER. So we are still really assessing the impact of the sequestration. I don't want to let Arati's final—or comment about contracts go without adding some additional context. Without getting into specific services, each week, Mr. Kendall gets a report on what is the impact of sequestration.

So there is a double hit with our contracting officers, because most of our contracting offices were undermanned to begin with

and people were being paid overtime. So it is not just going to be a 10 percent or 20 percent reduction. It is going to be more like a 40 percent reduction, because people will not get their overtime pay.

So contracting officers were working average 50- to 60-hour weeks, our junior level contracting officers. That will stop. That means that we are going to have a tremendous slowdown in being able to get money on contract. That will have a trickle-down effect to our subtier suppliers, our small businesses, and we don't know the impact of how that will play out. But it will hurt our sub-contractors, our big contractors, and will hurt the people who come in and try to make things happen for the Nation.

Mrs. DAVIS. I appreciate that. It is certainly a great concern. And I see, Ms. Miller, you had a comment.

Just on a slightly different note, I know that we are trying to consolidate some of the STEM programs, and the DOD was responsible for doing—I guess it is small grants, having some programs around, and now we are consolidating that more under the Department Ed [U.S. Department of Education]. Do you see that that is going to be impactful in terms of schools and some of the programs? Is there a way to minimize the effect of that kind of focus, which probably has a very positive effect, but may, in fact, have some consequences in terms of the ed programs? It is now under Department of Ed, but—

Mr. SHAFFER. Frankly, ma'am, the Administration believes that there will be efficiencies in consolidation of some of our STEM programs. There was a meeting at the White House this week of the principals, and they are trying to figure out how to fully implement that. We have until 2014 to figure out implementation.

I will tell you that STEM writ large is incredibly important to ourselves, to everybody on this panel. Preserving the workforce of the future is incredibly important. Unfortunately, last week, I had the privilege or—whatever you want to say is spending a week with our under secretary, Mr. Kendall, and he made sure that I understood that STEM programs would continue to be one of his highest priorities.

That is our future. And there are a number of disciplines where the DOD leads the Federal investment. We cannot allow and we cannot cede things like electrical engineering, mechanical engineering to other agencies. We are working with the White House and the Administration to try to get it right.

Mrs. DAVIS. Okay, thank you.

Thank you, Mr. Chairman.

Mr. KLINE. I thank the gentlelady. Your time is expired.

I do think it is interesting, when we look at STEM programs, the Federal Government, as of a report a little more than 2 years ago, has 209, and that is growing. It does seem to me we could get just a little bit more efficiency out of those programs, so I am delighted to hear that somebody in the Administration is thinking about cutting that down, presumably to something less than 209.

The President's budget assumes that sequestration disappears, but it is the law. And so in a hearing today, we were talking to the CNO and to the commandant and to the secretary of the Navy, and they were, again, saying that the President's budget doesn't

show sequestration numbers, but all of you have talked about the dire consequences of sequestration.

And then, Mr. Shaffer, in the President's request, I am looking here, I see there is a new defensewide program element called Applied Research for the Advancement of S&T Priorities, \$45 million in new money. So we don't have any money, and it looks like we are going to have less money because of sequestration. And yet you have a brand-new program element for \$45 million. What does it do that is worth more money, when we have all these other programs, and not to mention individual projects that may go away? Tell me about that investment.

Mr. SHAFFER. Yes, sir. I am happy to. So we actually took three, six, eight old programs and consolidated them down to one, because we believe in OSD in the power of competition. What that program element will do—and you heard us talking about some of these panels with SES leads in materials and human sciences and data to decisions.

Each of those panels now, that pot of money will be up for bid by these cross-cutting groups who want to do specific competitive ideas to prove out some concepts to move forward and move forward more rapidly. So rather than breaking things down into little stovepipes and telling this community, "You are going to have your \$5 million," another community, "You are going to have your \$5 million," this \$45 million bundled up old programs, and the concept now is we are going to have our cross-cutting panels compete and fund the very best ideas. So we want to fund the best ideas, not just tell folks they are going to have money just because they wake up and breathe.

So there will be small projects, but it will allow us to consolidate, coordinate, and make much more rapid progress, I think, in the cross-cutting areas that I mentioned, electronic warfare, cyber, EW. That is the concept. It is not new money; it is a consolidation and redirection.

Mr. KLINE. So a new program element, but old money that has been rolled together?

Mr. SHAFFER. Yes, sir. Yes, sir.

Mr. KLINE. That is somewhat reassuring, because every time I see now a new program, and they are all over the place—the President has a \$75 billion new dollar program in education——

Mr. SHAFFER. Sir——

Mr. KLINE. So my—thank you for that answer. And, by the way, thank all of you for your terrific work. Some of you I have known for some years. Some of you I have known for many years, particularly people sitting in the back rows back there, and there has always been a very soft spot in my heart for research and engineering for the DDR&E [Department of Defense Research and Engineering], for DARPA going back to the days of Vic Reis.

So thank you for the great work that you are doing, and I hope that you are getting at the questions that will come a couple of ways, of looking at how you are going to set priorities under a sequestration number, because while I think virtually everybody on this subcommittee and the larger HASC [House Armed Services Committee] would like to see sequestration go away so we can set

real priorities, it is the law, and we need some—a serious look at it from everybody, but certainly from you.

Mr. Langevin, you had some more questions, I think.

Mr. LANGEVIN. Thank you, Chairman.

So I know we have talked a lot about directed energy here today, and I would—you know, I do—I am definitely pleased that there has been substantial investment across the DOD in promising areas of directed energy research. But can you speak to the coordination of these investments across the S&T enterprise? And how is funding prioritized?

I mean, I am, you know, very much interested in getting the stuff out of the labs and actually getting it in the field, and, you know, the scientists tend to, you know, research this stuff to death, and yet—you know, according to the Center for Strategic and Budgetary Assessment, you know, this technology has progressed a lot further than what many realize and it is time to start fielding these things. So I want to know how you are coordinating across the enterprises.

Admiral KLUNDER. I can certainly take the first crack at this. And I will offer, the collaboration has been extremely valuable. I will look to my colleague at the right, the Army. In terms of their ground-based vehicles, they started some of the power source development for the laser system. My colleague to the left, Dave Walker and the Air Force, looked at a lot of the SWAP, the size, weight and power constraints that we have developing that power when they looked at their airborne aspects.

My colleague to the far left, Arati and I, are actually working on a higher level power source as we speak. The one that you are going to put—see on the USS *Ponce* is a certain level. We know that there is other aspects when we look at larger multi-mission aspects, I mean, the very, very sophisticated ones in a more classified venue, that we would certainly love to come talk to when you are—it is convenient. We need some additional power requirements that we are looking at and working together on.

So I think cooperatively there, I think the four of us—and then working through OSD is hugely supportive. I think that has been a success story of this one particular aspect, just one. There are others, obviously. I can pass to my other colleagues if they—

Ms. MILLER. Sir, I would like to add that the Army's laser is a joint high-power solid-state laser that was collectively developed with the High Energy Laser Joint Technology Office funding, Army funding, and then some funding in addition from the Air Force and the Navy, working on getting 100 kilowatt solid-state laser. That particular laser, while it was a laboratory design, the Army has put out at White Sands and is using with some beam apertures out there to actually do real-time testing of that laser in an environment to see what it can do.

As the Navy reported, we are also having great success in bringing down UAVs, but they are relatively easy. Our big target, we are trying to shoot down mortars and missiles, and we just this weekend shot down a 60-millimeter mortar with that laser.

Meanwhile, we understand that is a laboratory laser, and it certainly is not one that we will put on ground vehicles and go out and use. We are working on fiber laser development, again, collabo-

ratively, with the High Energy Laser Joint Technology Office, the Navy, and the Air Force to create a fiber laser capability with much more efficiency. Solid-state lasers are about 10 percent efficient. Fiber lasers, over 25 percent efficient. And we are pairing it up with a beam—a mobile beam director so that we can then put it on a ground vehicle.

Dr. WALKER. And the Air Force, as you have heard, has been working closely with the other two Services and with DARPA in developing our laser technology, both in the devices and the power sources for them. And the step forward that we are going to now is taking advantage of the work that has been done by the other Services and DARPA and taking it up to a mountain peak and shooting down to do what is of interest to the Air Force, is how do we mount this on an airplane and make it into a usable system?

And so we are currently starting—the first step is to take it and do the downward shot from a mountain peak and then be moving that to an aircraft, would be the next step.

Mr. LANGEVIN. Well, it is encouraging that this isn't siloed, and that there is good collaboration across the Services. So, finally, a question I have, as you know, the subcommittee has authorized several pieces of legislation over the past 5 years intended to improve the health of the labs. Section 219 of the fiscal year 2009 NDAA [National Defense Authorization Act] authorized the use of funds to support various local initiatives. We also authorized and raised the spending limits of the Laboratory Revitalization Demonstration Project, which is intended to support minor MILCON [Military Construction] projects.

Admiral Klunder, could you tell the committee how you use 219 and LRDP [Laboratory Revitalization Demonstration Program] to improve the conditions of your labs? And, more importantly, please let us know where we might improve upon those authorities.

Admiral KLUNDER. Well, first of all, I have to actually—I must thank you immensely for the help there and your staff, who we talk to on a regular basis. We truly couldn't have gotten those advancements in those labs and warfare centers without your help, and I thank you.

I do want to offer that we know in the fiscal environment that MILCON will be pressurized for the coming years, and certainly at the warfare labs and warfare centers, indeed, we see that pressure all the time.

Why I am so excited about what you were able to provide us here is that just for small, relatively small numbers, we can continue to make our warfare centers and our labs relevant through these modernization efforts. I don't think without your help we would have gotten there. I truly mean that. I am sure I can put my bid in for a MILCON proposition, and we do, but the reality is, it is—there are a lot of pressures. There are ships that have to go to sail. There are Army vehicles that have to go out and deploy, Air Force. And it just sometimes is going to be on the lower level when you fight out from MILCON.

So without your help, I don't think we'd have been able to make that. And I hope you can continue to give us that support, and we truly thank you and your staffs, sir.

Mr. LANGEVIN. Thank you, Mr. Chairman. I yield back.

Mr. KLINE. Thank you, sir.

Mr. Nugent.

Mr. NUGENT. Thank you, Mr. Chairman. And I want to thank the panel for being here, particularly as you support our warfighters and the technology that you are developing. They are going to save lives, particularly on our side.

You know, Dr. Walker, one of the things I think you mentioned in your testimony was about CHAMP [Counter-electronics High Power Microwave Advanced Missile Project], directed energy program, and I agree with, you know, Mr. Langevin, reference to, you know, getting it out of the laboratory and out into the field to our warfighters, you know, what we can do to move that along, maybe you could give me an idea—because I know CHAMP. We have spent \$40 billion, I believe, in development. I know it has been tested and actually has had positive results, so can you explain to me why we actually haven't put that out into the field?

Dr. WALKER. Certainly. CHAMP has been a long-term development in the laboratory, really turning the promise of high-powered microwave for ground attack into a reality.

We had a successful demonstration—I wouldn't say that we have fully tested it, but we have demonstrated that there is really a feasible capability. We had a successful flight test last fall, where we went against targets both soft and hardened and used the high-powered microwave to upset them.

The follow-on from that now is moving this forward into the acquisition process, where they are looking at capabilities and trading off concepts to determine whether or not this is something to go forward with into a follow-on weapons system. That is ongoing. In the meantime, the laboratory is continuing to develop better power supplies, better—high-powered microwave sources, so as to give the warfighter even greater capability as they go forward into an acquisition program.

And we are waiting to see the outcome of this concept development to see where we will go forward with this and whether we move into an AOA [Analysis of Alternatives] here in the near future.

Mr. NUGENT. And I guess the question for me is, what do you think the timeline is? I mean, obviously, it is always great to improve a weapon system. And I got three kids all in the Army, so I want, you know, the best and the greatest. But at the same time, I also want a capable weapons system to be deployed. You can always add on and do things to improve its accuracy or lethality, so—

Dr. WALKER. The timeline is a challenge right now, particularly in this fiscal environment, because we are having to make trades between other forms of attack, and where this fits in and when we will be able to afford it, I would have to take a question for the record here to give you an actual timeline of where we think we will be coming forward with the program.

[The information referred to can be found in the Appendix on page 147.]

Mr. NUGENT. I appreciate that. And I certainly want to continue to—I don't think I have to challenge you all to move forward, be-

cause I know that your hearts and minds are in the right places in regards to this.

But, Ms. Miller, from the Army, C-RAM [Counter-Rocket, Artillery, and Mortar], if you give me some additional information as to where we are and what we see in the future for C-RAM.

Ms. MILLER. Improvements to C-RAM?

Mr. NUGENT. Yes.

Ms. MILLER. Yes, sir. We certainly, from the Aviation Missile, Research Development, and Engineering Center, AMRDEC [Aviation and Missile Research, Development and Engineering Center], we have been investing in technologies to do affordable missiles that can go out and intercept RAMs [Rockets, Artilleries and Mortars], rockets, artilleries and mortars, and also UAVs, because, of course, as Admiral Klunder said in his opening statement, we have a cost paradigm where we are spending much more to defeat very inexpensive threats, and that is what we are trying to drive down.

So we have been designing affordable missiles that can go out and intercept, and also the directed energy solutions that we have talked to earlier are part of that equation.

Mr. NUGENT. And I would think the—your directed energy laser is much more—I don't know at this point efficient, but at least more cost-effective versus firing a missile?

Ms. MILLER. Certainly cost-effective once it is developed and when it is in use. The missiles that we are looking at, however, we are looking at very, very inexpensive missiles that can take out those threats, and that will be near-term. And the Army has a problem right now. We are certainly using C-RAM right now, and it is not the most cost-effective a solution, so we are looking at what we can do to drive down the cost of that capability and then bring on directed energy as soon as we are able.

Mr. NUGENT. Obviously, that is the—one of the futures that we have, is directed energy. And I appreciate my friend down the aisle there to keep the push.

And so thank you so very much.

Mr. KLINE. The gentleman yields back. We have all had an opportunity to ask questions. The chairman, the real chairman, said he had questions for the record. I think I am looking at them right here, so, staff, standby, quite a few.

Again, I want to thank you for being here today. I know it is not a great joy. I have never known anyone to spring for joy when they find out they are going down to testify on the Hill. So thanks for being here. Thanks for your absolute great work. Keep it up. And please, oh, please, start looking at those priorities under sequestration. I know somewhere you are, but we really need to be ready for that and see which projects and which program elements are going to survive and which ones aren't. And I know there is a lot of pain out there, but the sooner we start to step up to it, the better.

So, again, thank you very much. With that, the business is concluded. The hearing is adjourned.

[Whereupon, at 4:44 p.m., the subcommittee was adjourned.]

A P P E N D I X

APRIL 16, 2013

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

APRIL 16, 2013

HOLD UNTIL RELEASED
BY THE COMMITTEE

STATEMENT TESTIMONY OF

MR. ALAN R. SHAFFER
ACTING ASSISTANT SECRETARY OF DEFENSE FOR DEFENSE RESEARCH AND
ENGINEERING

BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON ARMED SERVICES

SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND CAPABILITIES

APRIL 16, 2013

Mr. Chairman, Ranking Member Langevin, members of the committee, I am pleased to be here today on behalf of the scientists and engineers in the Department of Defense laboratories, as well as the professional systems engineers and developmental test and evaluation personnel who work to conceive, develop, and mature systems early in the acquisition process. There are over 100,000 scientists and engineers performing these functions. These professionals have worked together, along with our partners in industry, academia, other governmental agencies, and allied partners to develop the capabilities and systems that have provided the unmatched operational advantage employed by the men and women of our Army, Navy, Air Force, and Marines, as well as other deployed US and allied personnel.

I also represent the office of the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)). Within the Office of the Secretary of Defense (OSD), ASD(R&E) is responsible for oversight of Department-wide activity from concept to early acquisition. Our Science and Technology (S&T) portfolio includes Basic Research, Applied Research, and Advanced Technology Development. The Research and Engineering (R&E) portfolio includes these budget activities as well as Advanced Component Development and Prototypes (ACD&P). ACD&P covers the technology transition from laboratory to operational use, and investment for prototyping which includes systems engineering and early developmental test and evaluation. Taken as a whole, these functions define the technical boundaries and possibilities of programs early in the Department's acquisition process.

When we step back and look at the capabilities developed and delivered by the Department of Defense research and engineering programs during the wars in Iraq and Afghanistan, I would contend that the nation has received a good return on investment. I will cite three examples of capabilities developed during the past decade that were developed and fielded from our ASD(R&E) programs.

- Foreign Comparative Test program identified and tested the first Mine Resistant Ambush Protected vehicle systems, vehicles that provide dramatically greater underbody protection for passengers.
- Quick Reaction Fund developed the Persistent Threat Detection System (PTDS) and Persistent Ground Surveillance System (PGSS) both of which are tethered aerostat systems that provide constant surveillance around our forward operating bases.
- Rapid Reaction Fund developed and produced the Jungle Advanced Under Dense Vegetation Imaging Technology (JAUDIT), a laser radar system that can map very high resolution topography and identify objects under canopy. The JAUDIT system transitioned to a major acquisition program of record in the Army; renamed Tactical Operational LIDAR (TACOP). As a next generation improvement to JAUDIT, TACOP is deployed operationally in Afghanistan today.

The Defense Advanced Research Projects Agency (DARPA) and the Services have also developed and fielded a myriad of capabilities for our warfighters. For instance:

- DARPA created and fielded a wide range of highly effective tools including the High Altitude LIDAR Operational Experiment (HALOE), a sensor that delivered three-dimensional views of the battle space to operational and intelligence users, and the Vehicle And Dismount Exploitation Radar (VADER), a radar pod that aided in the tracking of threat vehicles and adversary dismounted personnel.
- The Marine Corps Program Manager for Expeditionary Power deployed the Ground Renewable Expeditionary Energy System (GREENS), a portable hybrid photovoltaic/battery power system that contains stackable 1600-watt solar arrays and rechargeable batteries combined to provide 300 watts of continuous electricity while in remote locations – reducing the need for fuel resupply.
- The Air Force S&T program delivered Blue Devil Block 1, an intelligence, surveillance, and reconnaissance (ISR) asset. Blue Devil began as a response to satisfy multiple Joint Urgent Operational Needs (JUONs) and was delivered to theater in less than 280 days. It is the only ISR asset that integrates both wide and narrow field-of-view high definition day and night sensors. These technologies provide near-real-time information to troops while simultaneously providing forensic information to analysts. The Blue Devil ISR platform has now flown thousands of sorties and saved countless American, coalition, and civilian lives in Afghanistan.
- The Army's Clinical and Rehabilitative Medicine Research Program (CRM RP) made great strides in wound repair and organ/tissue regeneration. To date, ten hand transplants have been performed on six patients. CRM RP currently has burn repair technologies in clinical trials with industry partners to meet military needs.

These examples are only a few of the technologies we provide to the forces deployed in theater. These technologies have given our military unprecedented protection and situational awareness to address the counter-insurgency first we face today. The research and engineering community has performed remarkably to provide new and focused capabilities to our warfighter over the past decade and will continue to provide them into the future.

CHANGES IN SECURITY LANDSCAPE

Over the past decade, the nation and Department have been at war. The Department is now entering a new strategic period and the budget reflects changes in our mission. The strategic situation was well summarized by President Obama in the forward to the Defense Strategy “Sustaining Global Leadership: Priorities for 21st Century Defense.” On January 3, 2012, President Obama said in the forward to the strategy:

“As we end today's wars and reshape our Armed Forces, we will ensure that our military is agile, flexible, and ready for the full range of contingencies. In particular, we will continue to invest in the capabilities critical to future success, including intelligence, surveillance, and reconnaissance; counterterrorism; countering weapons of mass destruction; operating in anti-access environments; and prevailing in all domains, including cyber.”

On March 15, 2013, Secretary Hagel directed senior leaders to conduct a review to examine the choices that underlie the Department of Defense's strategy, force posture, investments, and institutional management. While Secretary Hagel has directed this review, the "Sustaining Global Leadership" document drove the development of the FY 2014 President's Budget Request just transmitted to Congress. The current budget challenges are forcing a review of the strategy but the S&T investment is crafted to address the still valid strategic challenges.

Secretary Hagel addressed the National Defense University on April 3, 2013. In this address, he highlighted the need to invest in technology during periods of austerity. He said:

"As the military grappled with incredible challenges to morale and readiness after Vietnam it also made the transition to an all-volunteer force and protected key investments in technologies like stealth, precision weapons, and platforms like the F-16 and Abrams tank. Even during the 1990s procurement holiday, we invested in satellite guidance and networking systems, as well as remotely piloted aircraft that have been game-changers during the last decade of war. The goal of the senior leadership of this Department today is to learn from the miscalculations and mistakes of the past drawdowns, and make the right decisions that will sustain our military strength, advance our strategic interests, and protect our nation well into the future."

While the future budget situation is uncertain, the emerging national security challenges are stressing the Department in ways that we have not seen in a number of years. These current challenges need to be dealt with, in spite of a declining budget. I will cite five emerging security challenges that the United States and our allies be prepared to address. They are:

- The instability in Syria, a state with weapons of mass destruction that could fall out of state control;
- The continued development by North Korea of its nuclear weapons and missile programs;
- The emergence of very sophisticated "anti-access, area-denial" capabilities in a number of nations that could prevent the freedom of movement and access of the US and our allies;
- The emergence of sophisticated cyber exploitation and attack; and
- The existence and increase in sophistication of advanced electronic attack capabilities of some of our adversaries.

While there are other emerging security challenges, each of the five challenges listed have strong technical challenges that should be addressed by the entire S&T enterprise.

SCIENCE AND TECHNOLOGY OBJECTIVES

The guidance is clear; the President and the Secretary of Defense depend on the S&T community to make key contributions to the defense of our nation. Those contributions can be summarized in the following three objectives:

1. Mitigate new and emerging capabilities that could degrade U. S. (and allied) capabilities
2. Affordably enable new or extended capabilities in existing military systems
3. Develop technology surprise through science and engineering applications to military problems

Each of these three objectives is important and is listed in order of priority. Collectively, the Services and Defense Agencies work together to address each of these objectives. The first objective is aligned with defense of the homeland. The second objective addresses DoD's need to make every system we own and buy more affordable. The final objective, after we ensure the defense of the homeland and the affordability of our current and future systems, is to develop new concepts and technologies that create technology surprise. Pursuing these objectives form the basis of a new strategy in response to the evolving security situation.

On April 19, 2011, then Secretary of Defense Gates approved seven S&T priority areas. These priorities are still valid, and support our emerging strategy. While each priority has elements for all of these objectives, three of the seven S&T priorities most strongly support mitigating emerging threats—Cyber, Electronic Warfare (EW), and Countering Weapons of Mass Destruction (C-WMD). One of the priorities, Engineered Resilient Systems (ERS), is directly aligned with affordability, and the final three focus on developing technology surprise—Autonomy, Data to Decisions, and Human Systems.

A key element of the S&T Defense enterprise are the Priority Steering Councils (PSCs) which are groups of Senior Executive Service members from each of the Services and Defense Agencies with investments in a technical area who work together to develop an integrated plan for their areas. Each of the seven S&T priorities has a PSC. We will describe the groups in more detail later, but these PSCs are integrating programs in technical areas across the enterprise.

A final element of the emerging strategy is to develop a better integrated R&E program across the entire Department. The job of OSD is to coordinate, integrate, and if possible, optimize the total Department-wide program. The Components do a good job developing Service-unique systems. We want OSD to focus on the technical areas where multiple Components have a substantial investment and provide coordination, integration and if possible, optimization across the Department. These technical areas align with areas no one owns but everyone uses. This includes space, cyber space, the electromagnetic spectrum, communications, and other specialty areas like materials science.

Objective 1: MITIGATION OF EMERGING THREAT

For a number of reasons, we are seeing an increase in the type and complexity of foreign systems and capabilities that could threaten the Department's ability to perform its missions. Examples of the new threats include, but are not limited to, cyber threats, advanced electronic warfare systems, counter-satellite systems, and proliferating short- and medium-range ballistic and cruise missiles. In addition, old threats, such as weapons of mass destruction (WMD), become more acute when tied to extremist terrorist groups. The R&E community must deal with all of these emerging threats. Many of the specific emerging concepts are classified, but we can make some general comments on how the Department is addressing the challenges. We will address several areas.

a) CYBER

The National Cybersecurity Coordinator, Michael Daniel, explained,

"The government's senior-most civilian, military, and intelligence professionals all agree that inadequate cybersecurity within this critical infrastructure poses a grave threat to the security of the United States. Most recently, we have seen an increased interest in targeting public and private critical infrastructure systems by actors who seek to threaten our national and economic security."

In 2011, we established the Cyber PSC to focus the Department's investment. The Cyber team is led by the Technical Director of the Air Force Research Laboratory in Rome, New York with representatives from the Naval Research Laboratory, U.S. Army Communications - Electronics Research, Development and Engineering Center, the National Security Agency, and OASD(R&E). This PSC is attempting to integrate the investments of all three Services, DARPA, and others into an integrated program. Across the Department, we estimate the investment in Cyber related S&T to be roughly \$500M in FY 2014.

The PSC has focused Cyber S&T investments into six areas:

- Foundations of Trust - Establishing foundational authentication, confidentiality, identity, attribution, and authorization services that support secure DoD operational use of cyberspace.
- Cyber Resilience - Having the ability to absorb damage and ensure continuity information technology in support of mission operations even in the face of successful and widespread cyber-attacks.
- Cyber Agility - Ensuring that systems can adapt and maneuver very rapidly in their configurations or location. By being a moving target in cyberspace, agile operations make successful attacks from our adversaries much more difficult.

- Assuring Effective Missions – Allowing commanders, decision makers, and operators to evaluate options, tradeoffs, and outcomes to enable the orchestration of cyber elements in support of kinetic and cyber missions.
- Cyber Modeling and Simulation - Developing M&S capabilities that are able to simulate the cyber environment in which the DoD operates and enables a more robust measurement, assessment and validation of cyber technologies.
- Embedded, Mobile, and Tactical - Focusing on unique cyber security challenges of the Department's weapons platforms and systems beyond wired networking and standard computing platforms.

I also want to highlight efforts that we are using to accelerate cyber as a science. The Cyber Measurement Campaign invests to develop new analytical methodologies, models, and experimental data sets to establish metrics to measure a system's state of security. Massachusetts Institute of Technology Lincoln Labs (MIT-LL) is the ASD(R&E) designated study lead for this cross-federally funded research and development center collaborative effort to start the campaign, determine its direction, and perform initial experiments in the areas of resiliency (Phase 1) and moving target technologies (Phase 2). Phase 1 goals were to demonstrate experiments to measure and quantify resiliency with mature research prototypes. Phase 2 is focused on moving target technologies, and will be evaluated during this year's Terminal Fury exercise at United States Pacific Command (USPACOM).

b) SPACE

As with Cyber, the last 5-10 years could be described as an era when the United States space constellation has become more vulnerable. Electronic jammers present challenges for U.S. global positioning, and communications satellites. Both the United States and China have demonstrated missiles against low-earth orbiting satellites. Other threat capabilities have left the U.S. in a position where we must better protect our space capabilities. Again, there are no easy answers to deliver capability, so we need S&T. In FY 2014, the Department plans to invest approximately \$550 million in Space S&T. While not all encompassing, our preliminary analysis shows three areas do need attention: precision navigation and timing (PNT), enhanced communications, and space resiliency. The first two are areas where, with S&T, the United States can reduce dependence on our current space architecture; the third area will begin the process of providing a new architecture.

1. Enhancement of Precision Navigation and Timing

The first area of engagement by the Department includes numerous activities to enhance the robustness of PNT. Currently, PNT capabilities are delivered primarily through the Global Positioning System (GPS), a system vital to numerous missions, ranging from conducting precision guided weapon strikes to synchronizing our communications networks. In an anti-access/area (A2/AD) denial scenario, it is reasonable to assume an adversary will seek to degrade or deny our use of GPS. The GPS program of record is pursuing modernization to further

improve the anti-jamming and secure access of the military GPS signals. These vital efforts must continue.

At the same time, the DoD S&T program is providing alternate means to provide PNT for our forces. For example, cross-Service efforts are in progress to develop next generation Inertial Measurement Units to reduce their inherent drift thereby increasing operational time and effectiveness in a GPS-denied environment. Army labs are pursuing efforts in relative navigation that will enable a combat team to determine their position even if only one element of a team knows its actual position. DARPA and the Navy are leading efforts to reduce the size of atomic clocks to bring GPS-quality precision timing into smaller systems. Additionally, we've reinvigorated efforts using non-GPS external references like ground/terrain features, RF signals, and stars -- each excelling for certain applications. These near- and far-term efforts are not intended to replace GPS. Instead they will provide robustness in environments where GPS-based capabilities are being degraded or denied either by environmental factors or adversary action.

2. Enhancement of Military Communications

Military operations depend on voice and data communications networks that have robust reliability that exceeds most civil communication infrastructures. Unfortunately, much like PNT, sophisticated adversaries could degrade our space-based communication networks. The S&T community is working to provide other options for secure communications to our operational forces. Robust, cyber-protected and adaptable networks are needed in all domains, as high-priority traffic travels in surface, air and space layers to achieve reliable connectivity.

To better understand assured communications, we have matured or initiated several efforts, including:

- The Battlefield Airborne Communications Network (BACN); is a Rapid Reaction Fund effort that has turned into an enduring podded capability to augment satellite communication, fielded in Afghanistan and headed to Pacific Command.
- The SpiderNet/Spectral Warrior program to enable spectrum awareness by network operators while we continue to assess the resiliency and control of space communications assets aimed at offering increased survivability and effective reactions within A2/AD conditions.

We are conducting a series of reviews with the Services to examine the need for alternative means, such as hosted payloads, new orbits, and layering of communications pathways across air and ground domains. One capability included in the FY 2014 budget is the Asymmetric Broadband Command & Control (ABC2) demonstration, an Iridium-based 'leave-behind' prototype that should assist in portable polar coverage in areas that traditionally experience sporadic and unreliable communications.

3. Enhancement of Space Launch Responsiveness

Finally, our current space architecture is comprised mainly of large satellites that may be vulnerable as some nations have demonstrated the capability to shoot them down. Again the S&T program should provide options. Recent technology developments, such as high resolution, small imaging focal planes, micro-inertial control systems, miniaturized thrusters and software programmable telecommunications, provide opportunities for DoD to employ low-cost, small satellites, ranging in the 10's to 100's of kilograms. When coupled with low cost launch systems this could enable an entirely new space architecture.

We have invested in two Joint Capabilities Technology Demonstrations (JCTDs) to examine these concepts. The Soldier-Warfighter Operationally Responsive Deployer for Space (SWORDS) JCTD provides a low cost, quick and predictable launch system for the Combatant Commanders and is capable of responding to urgent requests for augmentation of imagery or communications support. The Kestrel Eye JCTD provides the capability to deploy multiple imaging satellites to provide near-real-time situational awareness to the ground component warfighter. The major benefit of Kestrel Eye is the ability of the satellite to be tasked directly by the lowest echelons of command. This benefit is achievable since the satellite is expected to have a low per-unit cost (<\$1.5M) in production. With this low cost, sufficient numbers of satellites could be made and deployed to provide assured access, on-demand to the warfighter. Coupled together, these two JCTDs provide a glimpse of the future of affordable responsive space.

While constellations of small satellites cannot completely replace our need for the main-line Defense and Intelligence spacecraft, our ability to rapidly launch and, if necessary, quickly replenish constellations of small satellites to maintain essential warfighting capabilities could deter potential adversaries.

c) ELECTRONIC WARFARE/ELECTRONIC PROTECTION

The third emergent threat area is electronic warfare (EW) and electronic protection (EP). Simply put, the convergent maturation of multiple technologies has resulted in significantly new EW capabilities. The technologies include:

- Digital electronics
- New microelectronics providing increasing bandwidth, reliability, and agility of sensing systems including radar
- Digital/analog converters
- Photonics

These technologies can, through direct adaptation, provide potential adversaries capabilities that, in some case, could present operational challenges to U.S. forces and systems. Such developments, combined with longer range stand-off weapons and sheer numbers of jammers and decoys, represent a substantially different challenge for our forces, which for decades have routinely enjoyed virtually uncontested dominance in the use of the

electromagnetic spectrum. If left uncontested, this situation could result in circumstances that negate the value of some of our most expensive and sophisticated sensors and weapons.

As with cyber, the Department established the EW PSC, led by the Air Force with senior leaders from all the Services and OSD to guide and focus Departmental investments in EW. The EW PSC has been meeting to aggressively address the threats with a roadmap for coordinated development of EW capabilities. Within ASD(R&E) our Electronic Warfare and Countermeasures Office, in conjunction with the Research, Development and Acquisition (RDA) Task Force, initiated several efforts to regain U.S. dominance of the electromagnetic spectrum.

New emphasis is being placed on research and development to regain U.S. electronic component superiority to mature the next generation of electronic and photonic components with performance exceeding that of commercial-off-the-shelf (COTS) devices and to demonstrate these components in EW systems. To augment a substantial on-going EW S&T investment, the Department launched a pilot effort in FY 2013 to explore technologies that are essential to the superiority of future U.S. EW systems. EW S&T research, at the component and system techniques levels, is vital to the development of new, modern electronic attack and protection technologies for the future. Hand-in-hand with those key developments will be having the advanced testing equipment to facilitate the development of future EW systems.

Test capabilities should adapt to the reality of adversary sensors and weapons systems with advanced electronic components. In FY 2014, the Department has increased investment by \$480M over the future year defense program to provide major upgrades of our testing facilities to include advanced radar sensors to represent the digitally reprogrammable systems our potential adversaries are fielding. Not only do we need to test against advanced sensors but also we anticipate enemy weapons systems will be networked with sophisticated command and control functions. Upgrades to our test facilities will provide our advanced platforms with the signal densities from multiple netted sensors that they would expect to encounter in combat. These upgrades are not exclusive to open air ranges, although, that represents a significant investment. We are upgrading laboratory and anechoic chamber capabilities to the point that we will be able to employ electronic attacks and EP in software in the lab with threat representations validated by the intelligence community. As testing progresses through the lab, to the chamber, and finally to open air testing, we will progressively insert hardware in the loop while maintaining consistency in the signal environment.

d) COUNTER WEAPONS OF MASS DESTRUCTION

The final PSC in the emerging threat area, C-WMD, is focused on advancing the Department's ability to locate, secure, monitor, tag, track, interdict, eliminate, and attribute WMD weapons and materials. In FY 2014, the Department plans to invest approximately \$87 million in C-WMD. This investment only represents the funding aligned with finding loose fissile material. The Department recently concluded an interagency planning effort to define a robust S&T program to establish the science, technology base, and intellectual capabilities needed to support current and future C-WMD operations. Since 2011, the effort has been narrowly focused on finding and following nuclear materials. However, the products produced by the PSC to identify threat signatures and alternate ways of thinking about C-WMD, have

broad applications across the nuclear, chemical and biological domains. The Defense Threat Reduction Agency (DTRA) is the principal research agency in this domain and has support from all of the Military Departments and several Defense Agencies in performing and supporting relevant foundational research. Because DTRA is also a combatant support command, there is strong connectivity between the technical and operational challenges for this important mission. The DoD S&T program coordinates and collaborates with critical stakeholders, including the National Nuclear Security Agency, the Department of Homeland Security, and the Department of Health and Human Services. We also work closely with international partners in areas of mutual interest.

The S&T support in C-WMD ranges from fundamental research in the physical and biological sciences to more applied research for mitigating the WMD threat. The latter includes technologies for actively countering WMD weapons, sensors and personnel protection for chemical, biological, radiological, and nuclear (CBRN) threats, modeling and simulation of WMD effects, and medical countermeasures against chemical and biological threats. DoD S&T also develops tools for use in reach-back response to chemical, biological, or nuclear hazards. Technically, S&T continues to improve our detection and advanced sensors, both active and passive, and novel combinations of acoustic, radio-frequency, optical, and infrared sensing that may provide definitive detection and characterization and network analysis.

Objective 2: AFFORDABILITY ENABLES NEW OR EXTENDED CAPABILITIES INTO EXISTING MILITARY SYSTEMS

The second objective focuses on affordability, which includes affordability of new systems and their life-cycle upgrades, interoperability between existing platforms, and design and prototyping of new systems. All levels of leadership in the Department clearly understand the need to be thoughtful about each and every dollar we request and to carefully assess and justify the criticality of every item in our budget. As the Department shapes its future plan to reflect fiscal realities, it will continue to focus on efficiency and affordability in everything we do. Acutely aware of budget pressures, a key piece of our strategy is to make the most of our shrinking portfolio with the Better Buying Power Initiative. Our approach has been to maximize our investment dollars by improving design capabilities and making the transition of technologies to acquisition programs more effective and timely.

a) ENGINEERED RESILIENT SYSTEMS

One area where the Department has specifically focused attention on S&T to improve efficiency has been on the design process itself. As stated previously, one of our seven S&T priorities is ERS; an S&T objective that organizes work across the Department focused on rethinking the way we design and develop systems and to explore new concepts, tools, and processes to allow complex design to occur faster, smarter, and more cost-effectively.

The Department's investments in ERS form the bridge between S&T and future engineering and test capabilities that aim to make our warfighting systems more affordable and interoperable. In FY 2014, the Department plans to invest roughly \$470 million in ERS. The

S&T investment in ERS is focused on infrastructure, information, design and decision support tools, and knowledge environments that:

- Increase the speed of system development
- Improve effectiveness of fielded systems
- Minimize lifecycle costs

S&T efforts include integrating physics-based models with acquisition, quantifying the effects of architecture changes on system cost and performance, and automating trade-space analyses. ERS will leverage Department investments in human systems and data to decisions (D2D) to improve knowledge management and training during the entire lifecycle. By 2022, the goal of ERS is to achieve:

- A 75% reduction in the time to complete systems by reducing rework;
- A 100-fold increase in the number of parameters and scenarios considered in setting requirements prior to Milestone A;
- Quantified adaptability to changing mission requirements; and
- Integrated producibility and lifecycle concepts across acquisition

The Director of the U.S. Army Engineer Research and Development Center leads the ERS initiative with support from all the Components. The ERS lead monitors existing S&T programs, progress toward ERS goals, and identifies gaps in the S&T portfolio related to ERS.

b) SYSTEMS ENGINEERING INITIATIVES

Within the office of ASD(R&E), DASD(Systems Engineering) and DASD(Developmental Testing and Evaluation) perform additional functions mandated by the Weapon Systems Acquisition Reform Act of 2009. Each of these offices has considerable influence on acquisition success by ensuring that large acquisitions programs are properly planned, include appropriate engineering efforts to map requirements into technical specifications, realize those specifications in product and sufficiently test those products throughout their development. Both of these offices have undertaken significant initiatives to address acquisition affordability by ensuring better technical planning even earlier in the acquisition lifecycle – by engaging programs at the pre-milestone A stage.

The ASD(R&E) Systems Engineering office has led the Department's implementation of development planning, increasing early acquisition program planning and enabling the Department to make more informed early investment decisions based on a better understanding of technical risks and opportunities. DASD(SE) established the Development Planning Working Group (DPWG) in FY 2011, involving key requirements and acquisition stakeholders from across the Military Departments, OSD and the Joint Staff to ensure a common understanding and consistent implementation of development planning across the Department. The DPWG has been effective in developing clear guidance on early phase technical planning, providing sponsors and programs with a roadmap of how to better formulate and execute effective program plans from a program's beginning. With direct support to pre-major defense acquisition program, DASD(SE) has helped establish programs with realistic requirements, shape technical

strategies, and support a robust Analysis of Alternatives (AoA) process that assesses technical risks in areas such as reliability, maintainability, manufacturing, and schedule. DASD(SE) has worked directly with program offices to develop their Systems Engineering Plans, shape the Technology Development (TD) phase technical approach, and review the program's draft requirements, enabling informed requirements trade decisions that balance cost and performance and properly manage technical risks. By engaging programs early through development planning, DASD(SE) has helped to make the Department's senior leadership more informed about early acquisition investment decisions and more effective in planning and executing programs.

c) DEVELOPMENTAL TEST AND EVALUATION INITIATIVES

The DASD(DT&E) office has initiated an effort, entitled "shift left" designed to engage acquisition programs earlier in the life cycle, thereby ensuring a better understanding of program technical risks and opportunities before major milestone decisions. The basic premise of "shift left" is to find and fix problems before entering production. This should save money. There are three key focus areas to the "shift left" concept: earlier mission context, earlier interoperability testing, and earlier cyber security testing. Improved DT&E moves beyond the traditional technical focus to include testing in the mission context to characterize capabilities and limitations. Robust DT&E should also include all of the elements of interoperability and cyber security testing that previously was not tested until late in the acquisition life cycle.

DASD(DT&E) will focus attention on these areas and work with the Program Manager, Chief Developmental Tester, and Lead DT&E Organization to address these issues when they assemble the Test and Evaluation Working Integrated Product Team (WIPT) and write the Test and Evaluation and Master Plan. In the areas of interoperability and cyber security, DASD(DT&E) is working with all stakeholders to insert needed testing early and define the right way to oversee these processes. It is important that we be clear in our intent: our objective is to establish processes to oversee the developmental testing activities that support certification, not oversee the certification process. Simply put, DASD(DT&E) is working hard to improve the Service developmental testing functions.

d) DATA REUSE

The final specific area I would like to highlight is enhancing affordability through data reuse, led by the Defense Technical Information Center (DTIC). DTIC has the responsibility to develop, coordinate, and enable a capability to store, reuse, and apply technical information, data, and knowledge. DTIC has made tremendous strides in the past several years to evolve from a library function to an information exchange function, and in so doing has increased their support of the entire DoD R&E program. In this role, DTIC fosters information exchanges, empowers innovators with greater efficiency, effectiveness, and agility that supports accelerating the delivery of warfighting technology. The FY 2014 budget request for DTIC is \$56 million.

DTIC connects scientists, engineers, researchers and warfighters by enabling the R&E community to build on past work, collaborate on current challenges, avoid duplication of effort, accelerate fielding solutions at reduced costs, aid decision makers, and support management of the S&T Enterprise. DTIC registered 6,857 new users and supported 3,771 average monthly

active users in 2012. These new and returning users have increased usage of DTIC collections by 20%.

Bringing together the mix of performers in the lab, operational, and acquisition communities can pose technical and cultural challenges. Colleagues are separated by geographical and organizational structures. DTIC's information sharing efforts extend beyond official reports, to include researcher provided insights, areas for questions and answers, industry capabilities, and communication of DoD strategies and opportunities to industry. DTIC works to break down barriers by providing tools to support organization-to-organization connections and person-to-person interactions. Tools like DoD Techpedia hold an online electronic encyclopedia of knowledge and provide a platform where organizations can share information on challenges and needs. The Acquisition, Technology and Logistics community uses DoD Techpedia to support management of Major Defense Acquisition Programs (MDAPs). Another recently developed tool is called DoD TechSpace, a tool similar to Facebook, which allows teams to connect on work issues, share ideas, and link to experts.

To support our diverse stakeholder community, DTIC ensures appropriate users have easy access to relevant content while protecting sensitive data through information security, cyber security, and intellectual property safeguards. In support of the Better Buying Power initiative, DTIC develops tools to analyze and visualize Independent Research & Development (IR&D) investments for DoD decision makers to strategically invest scarce resources.

Objective 3: DEVELOPMENT OF NEW CAPABILITIES (TECHNOLOGY SURPRISE)

While the Department's S&T program is mitigating emerging threats and striving for greater affordability, completing just these two objectives is not satisfactory by itself. If all we do is react, the Department does not lead change. A critical component in the Department's ability to develop new capabilities is its investment in a wide range of basic research and applied research in new areas that have the potential to transition into major new technologies and capabilities. DARPA lives in this space. Objective 3 tends to be mid- to long-term focus and includes areas like quantum sciences, synthetic biology, engineered nano-materials, and many others.

I will start with the Department's investment in basic research, move through three PSCs that are focused on new capabilities (autonomy, D2D and human systems), discuss a special area, medical science, and then close with a new effort, to be hosted at DTIC, to better provide for technology watch/horizon scanning of emerging technical areas.

a) BASIC RESEARCH

The Department's Basic Research program has a long-standing history of investing in multidisciplinary and transformative research by leading scientists and engineers. The strength of its program is its ability to invest in research areas that have been identified as a priority to the DoD. The FY 2014 President's Request of \$2.2 billion with actual real growth compared to

inflation, highlights the importance and strong investment that the DoD places in its basic research program. This investment supports literally hundreds of individual grants.

While the Department invests heavily in traditional basic research areas like chemistry and material sciences, the Department also actively examines and assesses the global scientific landscape to identify emerging scientific research areas that may develop into game-changing technologies in the future. Some of these areas that we are focusing on for the future include:

- Synthetic Biology, where novel products in diverse areas such as bio-fuels, bio-sensors, vaccines, programmable devices, and high-strength materials.
- Quantum Information Science, whose applications might lead to new forms of secure communications, greater precision in the measurement of time and location, and simulation leading to development of new classes of materials.
- Cognitive Neuroscience, where increased understanding of brain function can inform researchers about human learning, decision-making, effective training methods, and the effect of stress, sleep, and post-war trauma on our military personnel.
- Understanding Human and Social Behavior, which can further our understanding of how individuals, groups, and nations work to enhance strategic and tactical decision making, improve immersive training and mission rehearsal, and facilitate cross-cultural coalition building.
- Novel Engineered Materials, such as superconductors, metamaterials, plasmonics and spintronics, which can be designed to provide novel coatings, self-healing properties, energy efficiency, and improved detection and computational capability to existing materials.
- Nanoscience and Nanotechnology, where increased understanding of material properties at the nano-scale can open doors to new classes of electronics and sensors, chemical catalysts, high-strength materials, and energetic properties.

In FY 2014, we are migrating the Historically Black Colleges and Universities and Minority Institution (HBCU/MI) program back to an OSD budget line, and re-categorizing the investment as basic research. The HBCU/MI research and education program strives to build the capacity of HBCU/MI to perform world-class research, as well as to involve students in that research to foster their interest in pursuing careers in science, technology, engineering, and mathematics (STEM) disciplines. As part of our administration of that program, we continually look for ways to increase the participation of HBCU/MI and ensure that we involve these institutions in activities of mutual benefit to them and DoD. Among our efforts during this past year was a very successful workshop where we brought together HBCU researchers from over 30 universities and their technical counterparts in the DoD research offices in a forum that allowed the researchers to talk about their research and understand DoD research priorities. We also seek to ensure that the research and education role of HBCU/MI is recognized as an integral part of the Department's larger research agenda by taking into account HBCU/MI viewpoints

and capabilities as we develop initiatives and address challenges for the longer term. In FY 2014 we plan to increase our HBCU/MI's investment to support the development of Centers of Excellence at HBCU/MI around cutting-edge research areas, such as cyber-security, autonomy, and D2D.

Since its inception in 1992, the DoD HBCU/MI program has funded over 750 research and education grant awards, including awards for investigator-initiated research and awards to acquire equipment and instrumentation. More than 160 HBCU/MIs received these awards, which totaled over \$350M. The 150 funded HBCU/MI included 75 percent of the designated HBCUs (76 out of 103) and about 85 percent the Tribal Colleges and Universities (30 out of 35), with most of the remaining awards going to Hispanic-Serving Institutions.

b) AUTONOMY

Autonomous technologies enable DoD warfighting systems to function with greater independence from human interaction and with reduced response times in stressed environments. The true value of autonomy is not to provide a direct human replacement, but rather to extend and complement human capability with autonomous systems. The Department's FY 2014 S&T investment in autonomy is approximately \$300 million and focuses on developing systems that perform complex military missions in dynamic environments with the right balance of warfighter involvement. Such autonomous systems can extend warfighters reach via unlimited persistent capabilities, offer warfighters more options and flexibility to access hazardous environments, and react at speeds and scales beyond human capability.

To implement autonomous capabilities, the Department has established four technical autonomy focus areas: Human and Agent System Interaction and Collaboration (HASIC); Scalable Teaming of Autonomous Systems (STAS); Machine perception, Reasoning and Intelligence (MRI); and Test, Evaluation, Validation, and Verification (TEVV) and has developed a capability development roadmap for each area.

Additionally, the Department established the Autonomy Research Pilot Initiative (ARPI), an initiative that will facilitate a coordinated S&T program guided by feedback from operational experience and evolving mission requirements. This program engages multiple Department laboratories on an internal, inter-service competition of autonomy-related applied research topics conducted by government scientists and engineers. The ARPI source selections are on-going for the work to be performed in FY 2014-2016.

Through the ARPI, the Department will allocate approximately \$15M for up to three consecutive years, totaling up to \$45M. Advancement of technologies from investments in the four technical areas will result in autonomous systems that provide more capability to warfighters, lessen the cognitive load on operator/supervisors, and lower overall operational cost. In addition, these investments will facilitate harnessing the potential of autonomous systems and strengthening mission effectiveness while maintaining fiscal responsibility and optimizing interoperability across space, air, ground, and maritime domains.

c) DATA TO DECISIONS

The second area to develop new capabilities is D2D which brings in elements of “big data,” data analytics, graph theory, and other emerging concepts in the knowledge domain. The 2012 National Security Strategy states that “for the foreseeable future, the United States will continue to take an active approach to countering [threats] by monitoring the activities of non-state threats worldwide[.]” D2D seeks science and applications to reduce the time and manpower associated with the analysis of large data, leading to actionable data. In FY 2014, the Department plans to invest approximately \$535 million in D2D. Investments in this new research priority area provides tools and insight into the widely available data to discover patterns and trends, analyze potential outcomes, and prevent strategic surprise. As a cross-cutting and enabling priority area, the research foundations of mathematics, statistics, and computational methods within D2D area are relevant across many of the missions and business areas within the DoD to include intelligence, operations, logistics, and personnel and readiness.

For intelligence data, challenges persist in analyzing the increasing amount of information resulting from improved sensor performance and the widely available and relevant open source information to support analysis and decision making. With this abundance of data, the need to discover and identify patterns, such as threat signatures, in complex, incomplete, imprecise and potentially contradictory large data sets has become a critical issue in decision-making processes within the DoD. It is beyond the abilities of humans to read and assimilate such large data sets and create comprehensive analytic products that leverage them. Said another way, as the amount of data grows, extracting actionable information, and fusing these results with relevant contextual or situational information to inform effective and timely action becomes progressively more challenging.

Some commercial technologies, such as cloud computing, are maturing and are widely available, but the development and use of data analytics to support DoD missions and business areas requires further research and development to exploit these advancements. Additionally, the unique challenges of the military tactical environment as well as the time and manpower constraints of tactical missions complicates adaptation of this technology as well as the development of data analytics to support mission requirements. On a much broader level, the foundations of D2D research can be used across many mission and business areas within the DoD to use data more effectively to save time and manpower costs.

d) HUMAN SYSTEMS

Human Systems research is focused on maximizing warfighter performance through focused and strategic research investments. The Department’s primary focus has been to foster true synchronization between the hardware, software, and human elements of warfighter systems. This synchronization will enable effective and efficient mission performance, training, and warfighter selection, as well as affordable and effective equipment to support and conduct military operations. In FY 2014, the Department plans to invest approximately \$270 million in human systems.

The Department’s Human Systems research is focused on three research areas: Personnel and Training, Human System Interfaces, and Biology-based Innovation. The research

area of Personnel and Training focuses on improving warfighter training so that they are not using yesterday's technology, methods, and strategies. The training must address evolving mission complexities and dynamics. The Department has made substantial progress in developing tailored training approaches, mission essential competency development, fleet synthetic training, intelligent adaptive training and enhanced cognitive competencies.

The research area of Human Systems Interfaces is addressing the problem that most of the Department's current operating systems are rigidly data-centric vice flexibly information-centric. Research in this area is addressing these challenges with the realization that data quantity will continue to increase nonlinearly. Substantial progress has been made in human interaction with autonomous system and command and control decision making.

In summary, the human sciences provide guidance on how to modify techniques, tactics, and procedures to achieve desired goals without an expensive materiel solution. Human systems research can provide tools for decision makers to evaluate whether non-materiel solutions or modified materiel-solutions can meet desired requirements at lower cost.

e) MEDICAL RESEARCH AND CAPABILITY DEVELOPMENT

A somewhat specialized area of investment in S&T is defense medical research. The Department's research efforts in the biomedical arena reflect the focus on taking care of our people throughout the full spectrum of operations to include prevention of injury and disease both in garrison and on the battlefield, diagnosis and treatment at the point of injury, delivery of world-class medical care both en route to, and within medical treatment facilities and rehabilitation. Over the past decade, we have made remarkable progress in research areas aimed at minimizing bleeding and preventing hemorrhagic shock. The major investments in medical research; however, focus on acquiring a better understanding of the underlying cellular mechanisms and functional impacts associated with traumatic brain injury (TBI), particularly those characterized as mild TBI or concussion. For the battlefield commander, it is important to quickly assess the extent of this injury after a blast or blunt head trauma, in order to get prompt and appropriate medical care for the warfighter. To this end, the Department's investment has led to the development of a high definition fiber tracking method for use with existing magnetic resonance imaging (MRI) scanners to assess brain tracts for damage with much greater sensitivity than ever before. Complementing this new imaging capability is the development of a blood test for TBI to determine if brain cells are physically damaged after a traumatic event. This test is now in pivotal clinical trials for approval by the FDA and if successful, this test is expected to be the first objective diagnostic test for the presence and extent of TBI that may become part of the gold standard by which this condition is diagnosed. With regard to brain functional assessment, the Department's research efforts have led to a novel method for assessment of brain injury that is based on eye tracking metrics. This technology will also benefit the operational community by enabling assessment of performance degradation due to stress and fatigue.

Finally, and quite amazingly, we are now deploying service members back into theater with ruggedized prosthetic legs that can withstand the rigors of the combat environment while dramatically improving agility. These new legs allow the user to move rapidly across uneven

terrain with improved efficiency. The Department is capitalizing on advances in understanding neuromuscular control to allow users to more naturally control prosthetic devices by harnessing nerve signals from the brain and linking them to the device. Although most of the investment in prosthetics has focused on the lower extremities, significant progress has been made in the development of a prosthetic arm that mimics the natural function of the human arm. Future investment will focus on reducing the weight and increasing the degrees of freedom in the motions that can be achieved by these prosthetic arms. Many of the Department's advances in rehabilitation are improving the quality of life of amputees in the civilian population as well.

Important to the development of injury prevention measures, is the knowledge and understanding of the mechanisms and forces involved in creating the injury. To this end, our S&T research program has developed a small, lightweight, multiple axis accelerometer/pressure blast injury gauge that is worn by the warfighter and is capable of storing the pressure and force profile of their exposure. This information, combined with associated medical symptoms, will aid in modifications of future designs of the warfighter's protective gear. These gauges are currently deployed.

f) TECHNOLOGY WATCH/HORIZON SCANNING

In the FY 2014 budget, we have a new low-cost, but high-risk effort to apply advanced data analytics to try to isolate and identify emerging "hot" science and technology areas. This type of approach is fairly well defined in industry for short-term financial prediction. We believe, but no one has proven, that the same non-parametric methods will apply to technology watch/horizon scanning. We will ask for industry bids to offer their software and modified for our purposes, then host the application at DTIC, for all DoD users to be able to access.

This is a high-risk initiative to bring emerging data analytics to bear on identifying significant changes in the global technology landscape. This effort will leverage a range of algorithms and data streams to provide both leadership and program managers more insight into evolving technical capabilities worldwide.

S&T INFRASTRUCTURE AND HUMAN CAPITAL

In order to execute programs that are designed to solve problems, an effective R&E enterprise must plan for and maximize its employment of people, facilities, and planning processes.

1. PEOPLE

Within the R&E functional areas, we have to both shepherd today's workforce, as well as develop the future workforce. Over the past several years, we have seen some initiatives that have increased our flexibility for hiring people – this has helped.

While previous legislation has helped with recruiting new talent, we have also made gains in the acquisition workforce due in part to the hard work of the Acquisition Career Field functional managers, three of whom reside in ASD(R&E) -- Science and Technology, Systems

Engineering, and Test and Evaluation. The Department's responsible officials for each are the Director, Defense Laboratories; the Deputy Assistant Secretary of Defense for Systems Engineering; and the Principal Deputy Assistant Secretary of Defense for Developmental Test and Evaluation. While we have made progress, I am concerned that the current budget and sequestration pressures will make retaining this workforce difficult.

a) SCIENCE AND TECHNOLOGY WORKFORCE

As part of the strategic workforce planning initiative, the Department has completed two assessments of its Scientist and Engineer (S&E) workforce this year – the Science and Technology (S&T) Functional Community assessment and the Technical Workforce of the Science and Technology Reinvention Laboratories (STRs) assessment. The S&T Functional Community assessment focused on the mission critical occupation of Computer Scientists indicated that there is increasing demand across the Department for highly skilled and highly trained individuals in emerging fields like cyber research, quantum computing, and artificial intelligence. The assessment also found that many of the skills necessary for the Department are best cultivated in-house because of the high degree of specialization needed and multi-disciplinary requirements. The SMART program (Science, Mathematics, and Research for Transformation) was identified as a critical tool for successfully attracting, training, and preparing the future workforce. Using SMART, we have been able to compete for very high-quality talent.

The Technical Workforce of the STRs assessment examined the more than 37,000 scientists and engineers working in the STRs. The assessment emphasized the successes of greater flexibilities for STRL directors that legislative changes have produced, particularly Direct Hiring Authority (DHA). DHA, which is available on a limited basis only for individuals with advanced degrees, has reduced the average hiring timeline from nearly 100 days to just under 30 days. This flexibility was identified as critical to hiring the most talented scientists and engineers in an extremely competitive market. Attrition due to retirement has been identified as potentially impacting the ability of the STRs to maintain the critical skills and competencies necessary to fulfill their mission. The assessment concluded that the ability of STRL directors to be flexible and adaptive in the management of their respective workforces is a key component to maintaining the scientific and technical excellence across the STRs.

b) SYSTEMS ENGINEERING WORKFORCE

The scope of the DoD engineering enterprise represents a remarkable investment of human capital. The Department, with its Services and Agencies, is one of the largest engineering enterprises in the world, with a non-construction Engineering civilian workforce made up of nearly 76,000 engineers. The DASD(SE) serves as the Department's Functional Leader for the technical subset of the Defense Acquisition Workforce, which includes the Systems Planning, Research, Development and Engineering (SPRDE) (about 39,000 civilian and military) and Production, Quality and Manufacturing (about 9,000 civilian and military) career fields.

Today's DoD weapons, combat systems, and technical activities provide unprecedented capabilities to the Department and presents engineering challenges to the Department's

engineering workforce. The Department has responded to these challenges, growing the SPRDE workforce 3.5% per year from 34,537 at the end of FY 2008 to 39,807 at the end of FY 2012. A strong government technical workforce balances the Department's partnership with industry by providing greater capability for the government to manage complexity and exercise technical judgment required to conceive, manage, invest in and oversee development of advanced weapon systems. In view of the programmed out-year weapons, combat systems and engineering initiatives, this workload, and the Department's need for world class engineering talent, is expected to continue well into the future. This environment will place greater pressure on the Department's ability to meet this continued demand for a multi-disciplined engineering workforce and adequately support increased program requirements.

The Department's engineering community has evolved over time to stay relevant to emerging defense challenges and, while systems engineering has always been an essential function, it becomes even more critical in a fiscally constrained environment. However, 12 percent of the SPRDE workforce is eligible to retire immediately. Many of the potential retirees will be those in senior and key lead SE positions on major defense acquisition programs. This highlights not only the potential loss of experienced SE workforce members, but also increases performance risks in programs and further highlights the need for the Department to continue support to maintain our engineering workforce as a national asset and critical function in support of the warfighter. DoD leadership is committed to further strengthening the systems engineering capability and capacity to assure there is a pipeline of qualified workforce members to serve current and future programs.

c) DEVELOPMENTAL TEST AND EVALUATION WORKFORCE

The DASD(DT&E) is the senior official responsible for the T&E Career Field in the acquisition workforce. DASD(DT&E) has also made significant progress in strengthening the T&E workforce, including revising the core education requirements to advance technical proficiency within the T&E profession, and the annual review to update the Defense Acquisition University T&E curriculum to enhance the T&E workforce's ability to meet tomorrow's challenges.

The current T&E acquisition workforce is 6,838 government and 1,765 military personnel for a total workforce of 8,603. The T&E workforce has increased from 7,420 in 2008 to our current level of 8,603. We continue to monitor impact of the budget pressures on the T&E workforce by providing assessments of the T&E workforce in future DT&E Annual Reports to Congress. The assessment will look at the ability to attract, develop, retain, and reward T&E experience to meet the needs of DoD.

d) SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)

In addition to taking care of today's workforce, the ASD(R&E) has responsibility for the S&E workforce of tomorrow. The Department depends on over 100,000 S&E as well as other STEM professionals. In 2011, we established the STEM Executive Board which provides strategic leadership to the Department's STEM initiatives. The Board is comprised of Senior Executive Service-level representatives from the Services; USD Personnel and Readiness;

Intelligence; and representatives of key acquisition Components, and provides strategic coordination of DoD's STEM investments. Specifically, the STEM Strategic Plan and Implementation Plan align the Department's investments with DoD STEM workforce requirements and with Administration STEM guidance, including robust, on-going impact assessments.

The future of the Department's STEM workforce depends on a robust education system that provides diverse pathways into STEM to meet the Department's mission. Numerous studies in recent years have called our attention to the need to improve STEM skills of U.S. students, who have fallen behind other nations. Through basic science workshops, increased funding for university research and other dedicated STEM programs, we are trying to stay connected to universities.

Within the ASD(R&E) portfolio, we have the National Defense Education Program (NDEP). This program supports the scholarship-for-service Science, Mathematics, and Research for Transformation (SMART) program, which provides financial support for undergraduate and graduate degrees in 19 STEM fields that are critical to the Department's future. Under SMART, we have attracted over 1,500 top quality researchers. To date over 700 students have completed their degrees and entered the DoD workforce. Of these, 82% remain employed in the DoD beyond their service commitment. We continue to make use of the SMART program to improve our workforce.

2. FACILITIES

As part of a much larger Office of Science and Technology Policy led effort to assess the overall status of infrastructure at our government labs dedicated to national security, the Department is currently conducting an assessment of Defense Laboratory facilities in order to more quantitatively and comprehensively evaluate the current state of DoD Laboratory facilities. The Department is also examining the process of how the Services currently prioritize military construction projects and how Laboratory projects are evaluated in this context. There are general concerns both within and outside the Department that Laboratory facilities are underfunded relative to the non-lab infrastructure in the Services. We are in the process of determining quantitatively if this is true. Without quantitative evidence, it is impossible to develop proper solutions that adequately address any problems.

Through this study, the Department will also be able to quantify the nature and scope of deficiencies at the Laboratories and the potential costs of rectifying them. Anecdotal evidence suggests that Laboratories' sustainment, restoration, and modernization efforts lag those of the rest of the Department, but by how much and to what extent is unclear. The successful uses of the expansion of minor military construction authorities to Laboratories suggest that there are indeed gaps, and the Department is committed to eliminating them. With a more accurate understanding of any gaps and their size, the Department can take the necessary steps to ensure that our Laboratories' facilities remain state-of-the-art and capable of supporting today's mission and future requirements.

In addition to quality laboratories, the Department also needs high-quality test facilities. Planned T&E infrastructure upgrades have been partitioned between System Integration Laboratories (SIL), Installed System Test Facilities (ISTF), and Open Air Ranges (OAR) investment to provide a capability mix that effectively supports technology experimentation and design performance verification testing. This investment benefits S&T through providing more modern and representative test facilities. Planned upgrades are focused in three investment areas. First and foremost, the Department is improving its System Integration Laboratories at Eglin Air Force Base, FL and Naval Air Station Point Mugu, CA to allow programming of flight test mission data files and EW libraries to reflect foreign integrated air defense systems (IADS) threats. As mentioned earlier, the Department is upgrading our next-generation EW emulators to mimic modern IADS and finally, we are upgrading open-air ranges to better iterate live-virtual demonstration exercises.

We are also very interested in enhancing our cyber test facilities. The increasing demand for cyber test, training, and experimentation will challenge our capabilities and capacity of our cyber ranges. We have transitioned the National Cyber Range (NCR) from DARPA to the Test Resource Management Center (TRMC), where we will operationalize its capability to support test and training. The Department will continue investment in this critical infrastructure to increase both capacity and capability for cyber training, testing, and experimentation. Once operational and accredited for the required level of classification, the NCR will have increased capacity, with standard services, more efficient sustainment of capability, and fail-over capability to improve Cyber R&D.

3. DEPARTMENT R&E PLANNING PROCESS

A key strength of DoD's S&T Enterprise is its substantial emphasis on coordinated research planning. The Department's S&T components devote great care and attention to ensuring that DoD's research investments are well planned and coordinated. In these challenging budgetary times, it is important to strengthen these efforts to ensure that we receive the utmost value from our investments in science and technology.

The overarching framework of the Department's S&T joint planning and coordination process is called Reliance 21. We are resurrecting and enhancing Reliance 21, a process with roots that go back several decades, which has undergone continual renewal and refreshment as circumstances evolved. The Reliance 21 framework is led by an S&T Executive Committee (ExCom) that embraces the major Departmental S&T organizations, including the Military Services and DARPA who sit at my side at this hearing today. The S&T ExCom, and the S&T Deputies Committee that serves as its primary operating arm, meet several times per month to coordinate both strategically and at a tactical level to harmonize resources and coherently address emerging challenges. Once every year, the 3-star and 2-star members of the S&T ExCom conduct an intensive multi-day planning exercise of the Department's out-year research investments, to ensure proper attention to potential gap areas, and to minimize unwarranted overlaps. This event is conducted in close coordination with the future requirements specialists of the Joint Staff.

Underpinning the S&T ExCom leadership is an ecosystem of technical groups known as Communities of Interest (CoI) and S&T Priority Steering Councils (PSCs). There are 18 of these groups that span almost all of the cross-cutting areas of science and technology in the Department. Examples of such areas include Advanced Electronics, Sensors & Processing, and Cyber security, among many others. These groups are populated by the Department's subject matter expert leaders drawn from the Services, Defense Agencies, and from OSD. The subject matter experts often have decades of experience in the Defense S&T research enterprise and are an asset in DoD's efforts to generate technology surprise and rapidly convert that surprise into operational capabilities. Fundamentally, the subject matter experts guide and coordinate the portfolios of research investments in each of the CoI and PSC areas. They do this primarily through development of research roadmaps and investment plans. The roadmaps are used extensively to guide long-term budget decisions and to influence near-term investment decisions in each of the Components. The CoIs and PSCs also provide forums for developing younger staff and for maintaining technical awareness of S&T developments both inside and outside DoD. Each year, roughly half of the PSCs and CoIs brief the health, direction, and connectedness of the programs in their portfolio.

In addition to this coordinated approach across the Department, we have taken steps to better leverage Industry's Independent Research & Development (IR&D) for which DoD reimburses industry approximately \$4 billion annually. IR&D projects are a critical source of technology innovation for DoD. Under the Better Buying Power initiative, ASD(R&E) was charged to reinvigorate IR&D. The key challenge identified was communication – industry wanted information about Department investment priorities to help them better plan their IR&D projects, and DoD planning was hampered by limited insight into industry IR&D projects. The Defense Innovation Marketplace website (www.defenseinnovationmarketplace.mil) was developed to provide a one-stop-resource for Department priorities so industry could better align their R&D investments. Industry can also securely share IR&D projects with the government, allowing S&T and acquisition program managers to leverage this data to inform future program planning.

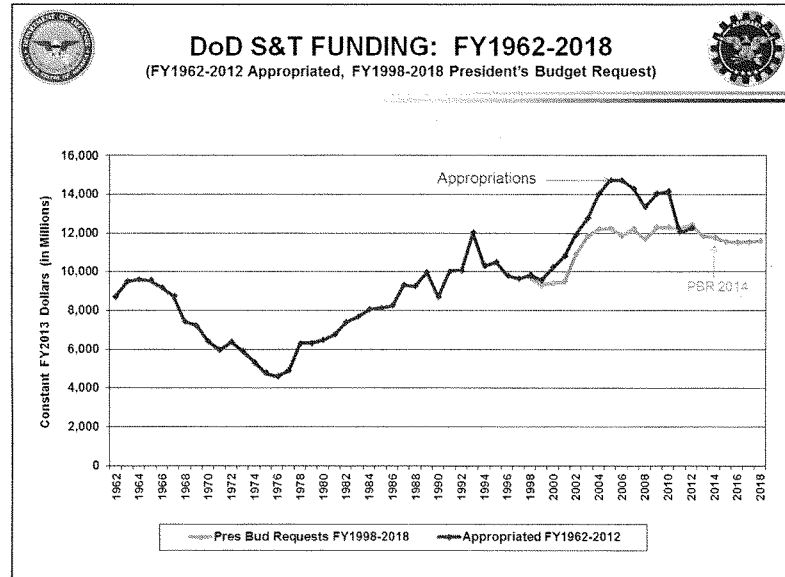
BUDGET PRIORITIES

1. DoD S&T TRENDS

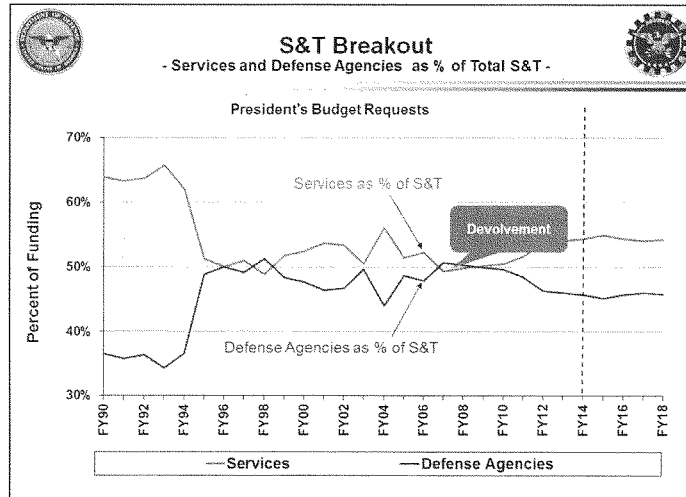
The FY 2014 President's Budget Request (PBR) for S&T is \$11.98 billion, which represents a nominal growth from the FY 2013 PBR of \$11.86. For R&E, the FY 2014 PBR is \$24.04 billion, which is a 2.6% decline from the FY 2013 PBR of \$24.27 billion. This is because the budget category of Advanced Component Development and Prototypes declined 4.47%, in real buying power. See table:

(\$B)	PBR 2013	PBR2014 (FY13 CY \$)	% Real Change from 2013 PBR
Basic Research (6.1)	2.117	2.164 (2.128)	.53%
Applied Research (6.2)	4.478	4.627 (4.549)	1.59%
Advanced Technology Development (6.3)	5.266	5.192 (5.105)	-3.06%
DoD S&T	11.861	11.984 (11.782)	-.67%
Advanced Component Development and Prototypes (6.4)	12.409	12.057 (11.854)	-4.47%
DoD R&E	24.270	24.040 (23.636)	-2.61%
DoD Topline Budget	525.449	526.637 (518.854)	-1.26%

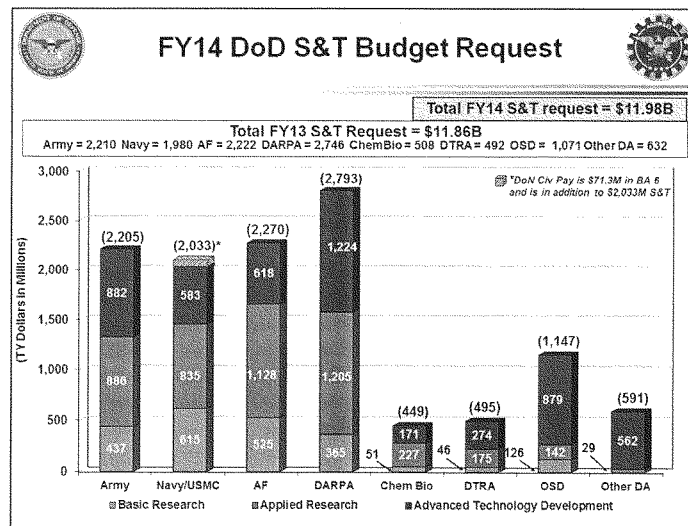
We must continue to balance the investment with all our partners across Acquisition, Technology and Logistics. We also recognize R&E provides lower cost options which become more important during budget austerity. The FY 2014 President's Budget represents a strategic choice made by the Department to preserve, to the greatest extent possible, technology-based options for the future. While we expect continued pressure on the S&T and R&E budgets over the next several years, it is significant to note that there is recognition of the value of preserving future options—a characteristic of R&E. Taking a longer term view, the chart below shows the actual S&T investment in constant year 2013 dollars, since 1962. The budget request for S&T has been largely flat since about 2003. This highlights another key characteristic of a healthy S&T program: long term stability. It is important to not have big fluctuations in R&E funding from year to year so as to maintain a stable workforce.



Another macro trend we see in the DoD S&T budget is highlighted in the next chart. Since the FY 2008 President's Budget Request, we have made a conscious choice to focus more of the investment to the Services, in relation to Defense Agencies and the Office of the Secretary of Defense. We still have an investment of \$5.48 billion in the Defense Agencies and the Office of the Secretary of Defense for S&T in FY 2014, but this is down from a figure of \$6.09 billion as recently as FY 2010. Much of these funds were with programs that devolved to the Services.



Finally, the chart below displays the S&T investment by major Components. Investment in S&T for the three Services is between \$2.0 and \$2.2 billion and DARPA remains the single largest investment with \$2.8 billion in FY 2014. The other components make up a much smaller piece of the S&T portfolio.



The FY 2014 S&T budget also supports White House priorities in the areas of advanced manufacturing, robotics and autonomous systems, cyber security, hypersonics, and electronic warfare described in earlier sections.

2. ASD(R&E) PORTFOLIO

Shifting focus from the overall DoD S&T to the ASD (R&E) investment portfolio, the FY 2014 S&T budget of \$738 million is 5.5 percent higher than FY 2013 budget of \$700 million. The FY 2014 budget reflects a significant change in major investments that align to the defense strategy, DoD S&T priorities and OMB priorities described above. These FY 2014 S&T investment changes include:

- Termination of 5 existing programs/program elements to create a new \$45 million 6.2 Applied Research for the Advancement of S&T Priorities Program to focus on the 7 S&T priorities, applied research projects, concept explorations, and technology solutions for future military needs. In FY 2014, this new program will support the aforementioned autonomy pilot and acceleration of engineered resilient systems. The remaining funds will be competitively allocated to the other PSCs generated proposals. All funding in this program will be executed by the Components.
- Transfer of responsibility and \$16 million in funding for the Historically Black Colleges/Minority Institutes program from Army to OSD consistent with the FY 2012 National Defense Authorization Act including realignment of additional \$15 million for Centers of Excellence.
- Realignment of \$13.8 million in the Emerging Capabilities Technology Demonstration program to address developmental prototyping.
- Realignment of \$60 million from 3 existing programs for the standup of a new Strategic Capabilities Office (SCO) responsible for analyses of emerging threats with emphasis on innovative and architecture-level concepts, intelligence concepts, red teaming, and conducting disruptive technology demonstrations.
- Realignment of \$130 million for the Advanced Innovative Technologies Program to accelerate a land-based prototype of an electromagnetic railgun for improved theater missile defense capability. This program is not S&T, but ACD&P.

LEGISLATIVE PROPOSALS

PRIZE AUTHORITY

The Defense Budget Priorities and Choices guidance, issued in January 2012, calls for “cutting-edge capabilities that exploit our technological, joint, and networked advantage.” Extending the authority for Prizes for Advanced Technology Achievements, requested by this proposal, will allow the Department to continue the cutting-edge technology prototyping that

results from the prize challenges. Partnerships created under this legislation also strengthen the ties of the Department with industry and universities. Prize competitions are unlikely to replace the traditional acquisition process in the DoD, but for specific technology problems, it is a method that has demonstrated to be tremendously useful for stimulating and incentivizing a broad spectrum of individuals to offer solutions to problems of significant interest to our Nation's Warfighters.

SMART

The Science, Mathematics, and Research for Transformation (SMART) is a Scholarship-for-Service program designed to produce the next generation of DoD S&T Leaders as our current workforce is aging and eligible to retire. The program accomplishes this goal by providing support to undergraduate and graduate students for their educational expenses in exchange for service in our DoD facilities. This program matches the SMART scholars with DoD laboratories and other Defense agencies where mentors transfer their STEM knowledge to the students and introduce them to the DoD culture beginning with internships and culminating in full-time employment at those facilities. The Department is asking for a revision of the SMART legislation that would create three major benefits; (1) increased flexibility to administer the program, (2) reduced stipends to make them more consistent with other Federal scholarship-for-service programs, and (3) removal of the restriction that only United States citizens can participate in the program.

SOFTWARE LICENSING

The DoD develops significant quantities of computer software in a variety of areas such as modeling and simulation, training, and command and control. A legislative proposal has been prepared to allow the DoD to protect its software and to facilitate the license process for transfer to commercial firms. In the course of that licensing action, it would be protected from release to the general public in response to a Freedom of Information Act request for up to five years providing the commercial licensing partner adequate time to develop the product, prepare user documentation, and deploy to both military and commercial markets. At the same time the commercial firm's investment of funds to underwrite these product activities is protected from undue competition. The request is for a 5 year limit on this pilot program. This provides adequate time for DoD to develop data that would justify a future request for extension, modification, or cancellation of this authority.

SUMMARY

I would be remiss if I did not mention the impact of sequestration. At the macro level, the reduction to S&T investment is roughly \$1 billion in FY 2013. Since in many cases, the work in S&T is sequential, the work planned for FY 2013 will be deferred to FY 2014--and reduces the work planned in FY 2014 by that same \$1 billion. Some of this reduction will be seen at our government labs, but other impacts will be seen in government and universities. For example, we expect the total investment in universities to decline by about \$250 million.

In closing, I am proud to say our R&E enterprise is delivering capability and value for the Department and Nation. I would also like to thank Congress for your continued support of the S&T program of the Department of Defense. As we enter a new strategic era, it is important to examine all Department investments. It is just as important to understand the value of investments like R&E that strengthen the overall capabilities of the Department. With your support of the FY 2014 President's Budget request for RDT&E, you will allow our community to continue to deliver future capabilities for the Department.



Mr. Alan R. Shaffer
Principal Deputy, Assistant Secretary of Defense for
Research and Engineering

Mr. Shaffer serves as the Principal Deputy, Assistant Secretary of Defense for Research and Engineering. In this position, Mr. Shaffer is responsible for formulating, planning, and reviewing the DoD Research, Development, Test, and Evaluation (RDT&E) programs, plans, strategy, priorities, and execution of the DoD RDT&E budget. Specifically, this position reviews the maturity of technology as part of the acquisition cycle, as well as develops options to reduce the overall technology development risk to DoD programs.

Prior to entering the federal government, Mr. Shaffer served a 24-year United States Air Force career with assignments in weather, intelligence, science and technology management, acquisition oversight, and programming. His career included deployment to Honduras in support of Joint Task Force Bravo in the mid-1980s and direct support of the United States Army 3rd Armored Division at Hanau, Germany. During Operation DESERT STORM, he was responsible for deployment of the 500-person theater weather force. Other assignments included Wing Weather Officer supporting the 320th Bombardment Wing (Heavy) at Mather AFB, California; Intelligence Officer at Foreign Technology Division, Wright Patterson AFB, OH; Deputy Director of Weather for Air Combat Command, Langley AFB, VA, numerous staff assignments in the Air Staff and Office of the Secretary of Defense, in the Pentagon; and finally, the Air Force Weather Agency, Offutt AFB, Nebraska.

Upon retirement from the United States Air Force in 2000, Mr. Shaffer was appointed to the Senior Executive Service as the Director, Multi-disciplinary Systems, Office of the Deputy Under Secretary of Defense for Science and Technology. In 2001, he assumed the position as Director, Plans and Programs, Defense Research and Engineering. Mr. Shaffer continues to serve as the Director while serving as the Principal Deputy. As the Director for Plans and Programs, Mr. Shaffer is responsible for the oversight of the Department of Defense science and technology portfolio totaling over \$10.5 billion. Mr. Shaffer has served as the Executive Director for several senior Task Forces. These included the Technical Joint Cross Service Group during the Base Realignment and Closure activity; DoD Energy Security Task Force in 2007 and most recently the Executive Director of the Mine Resistant Ambush Protection Task Force. In addition he serves as the tri-chair to the Department of Defense Modeling and Simulation Steering Committee.

Mr. Shaffer earned a Bachelor of Science Degree in Mathematics from the University of Vermont in 1976. He earned a second Bachelor of Science in Meteorology from the University of Utah, a Master of Science in Meteorology from the Naval Postgraduate School, and a Master of Science in National Resource Strategy from the Industrial College of the Armed Forces. He has been awarded the Distinguished Executive Presidential Rank Award in 2007 and the Meritorious Executive Presidential Rank Award in 2004.

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STATEMENT BY
MS. MARY J. MILLER

DEPUTY ASSISTANT SECRETARY OF THE ARMY
FOR RESEARCH AND TECHNOLOGY

BEFORE THE
INTELLIGENCE, EMERGING THREATS AND CAPABILITIES
SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE UNITED STATES ARMY'S SCIENCE AND TECHNOLOGY (S&T)
PROGRAM FOR FISCAL YEAR 2014

FIRST SESSION, 113TH CONGRESS

April 16, 2013

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UNITED STATES HOUSE OF REPRESENTATIVES

**STATEMENT BY
MS. MARY J. MILLER
DEPUTY ASSISTANT SECRETARY OF THE ARMY
FOR RESEARCH AND TECHNOLOGY**

Mr. Chairman, Ranking Member Langevin, and distinguished members of the Subcommittee, thank you for the opportunity to discuss the Army's Science and Technology (S&T) Program for fiscal year (FY) 2014.

Over the course of these past almost twelve years of war, the world has seen first-hand the value and impact that technology brings to the battlefield and how capabilities, enabled by technology, are critical to our Soldiers and their success. The U.S. Army depends on its S&T Enterprise to research, develop, and demonstrate high pay-off technology solutions for hard problems faced by Soldiers in ever-changing, complex environments against an increasingly diverse set of threats. Uncertainty and complexity are at the heart of the Army's challenges. The Army of the future requires solutions that are both affordable and versatile and relies on the S&T community's contributions to ensure that they remain the most capable in the world. We are grateful to the members of this Committee for your sustained support of our Soldiers, your support of our laboratories and centers and your continued commitment to ensure that funding is available to provide our current and future Soldiers with the technology that enables them to defend America's interests and those of our allies around the world.

To ensure our effectiveness in meeting the Army's needs, the S&T Enterprise must remain innovative and agile, staffed with scientists and engineers who can develop solutions for identified problems while understanding the constraints that

Army operations require. The overarching vision for Army S&T is to foster innovation, maturation, and demonstration of technology that provides increased capability to the Warfighter. Our mission includes the transition of both the understanding and knowledge acquired while developing technology solutions as well as the materiel. While the very nature of S&T puts our focus clearly on providing capabilities for the future, we continue to exploit opportunities to transition solutions to the current force.

Strategy

As the war in Afghanistan draws down and budgets decline, it is clear that we, the Department of Army, have some significant choices to make. We are facing an environment in which we have procured a lot of military equipment over the past decade. Systems such as the Mine-Resistant Ambush Protected (MRAP) vehicles, which proved to be so valuable to saving the lives of Soldiers in both Iraq and Afghanistan, will now join the ranks of the Abrams, Bradley and Stryker as a part of our Army combat capability. The Army is assessing which urgently fielded war-time systems will come back and join the ranks of formal programs of record as a part of our enduring Army capability. These decisions will, by necessity, impact the Army strategy for future investment and research.

This is not the only impact, however. The National Military Strategy and its focus on operations in the Pacific Rim adds another level of complexity. As we expand our focus from the current fight to prepare for the future, we find ourselves in a situation where we may face a more capable enemy in an environment that is much more contested and complex. Our recent experiences, while challenging, have been against a less technically astute enemy. Our focus has been on mitigating those threats to the troops. The next fight may well be against a near-peer capability – one for which we have not fully prepared. We intend to avoid the old adage that we always prepare to fight the last war. We are investing now to understand our potential vulnerabilities and in developing capabilities that will help us be prepared for a more technically savvy opponent.

Given the current budget environment and prospects for funding in the future, it has become even more important than ever that we clearly understand our current capabilities and what we need in the future as we face ever evolving threats. With that in mind, the Army has initiated a comprehensive investment and modernization strategy to better facilitate informed decisions based on long-term objectives in a resource constrained environment.

The Army traditionally plans and budgets through the Program Objective Memorandum (POM) process. This five year look allows us to project with a fair level of certainty what we are doing in the next few years, but it does not lend itself well to making decisions with an understanding of how those same decisions impact the Army of the future. The desire to look more holistically across the lifecycle of programs and to facilitate better decisions was a key driver to establishing a new process within the Department of the Army.

To that end, the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA(ALT)) has initiated the Long Range Investment Analysis (LIRA) process where the Army looks out 30 years beyond the POM at the equipping and sustaining needs of the Programs of Record (PoRs). This longer-term approach covers the entire acquisition lifecycle, to include sustainment. With the renewed emphasis on assessing the impacts of near-term investment decisions on the life-cycle costs and desired capabilities of PoRs, it is increasingly important to have a sustainment strategy that is synchronized with the modernization strategy. It is essential to align S&T investments to support these PoRs and to understand where we can capitalize on opportunities for insertion of new, more affordable capability.

The LIRA feeds well into the ASA(ALT)'s desire for a more strategic modernization plan. This approach to modernization includes an awareness of existing and potential warfighting gaps, an understanding of emerging threats, knowledge of state-of-the-art commercial, academic, and government research, as well as a clear appreciation for the competing needs of limited resources.

I recognize that projections of this length are rarely accurate. However, going out 30+ years requires us to think beyond the easy answer of just doing what we are doing now but for a bit longer. It forces a new look at what else might need to happen. The world of 2040-2045 is clearly NOT going to look like the world of today. The threats we face and capabilities needed to address those threats may in fact look very different than what we have fielded today. To prepare for an uncertain future requires an approach to modernization that includes an awareness of existing and potential threats, an understanding of peer nation capabilities, knowledge of state-of-the-art commercial, academic, and government research, as well as a clear understanding of competing needs for limited resources. This is done through close collaboration with the Office of the Secretary of Defense (OSD) and the Intel Communities to not only assess foreign systems that we see under development but to conduct a technology watch that can provide indicators on what foreign countries are investigating that may become our next set of threats. This exercise challenges us to look at those eventualities.

This new way to approach our planning has put rigor into the analysis and forces the communities who pay for the development of materiel and the long-term sustainment of materiel to work together to maximize the Army's capabilities over time. From an S&T perspective, it clearly starts to inform the community as to when technology is needed for insertion as part of a planned upgrade. It also cues us as to when to start investing for replacement platforms. A great example of that is our aviation portfolio where we are conducting the S&T underpinnings of the next PoR planned to replace both the AH-64 Apache and UH-60 Blackhawk. The Army S&T community has already initiated the Joint Multi-Role Technology Demonstrator (JMR TD) effort as the foundation for the Army's Future Vertical Lift (FVL)-Medium PoR. This demonstrator program will create two flying prototypes that will help inform requirements for the FVL-Medium as well as define what should be asked for within the Request for Proposal. The S&T tech demo is being well coordinated with Program Executive Office (PEO)

Aviation and the Aviation Center of Excellence at Fort Rucker to ensure that we are working a solution that will fit and inform the Army's needs.

Aside from the obvious benefit achieved by laying out the Army's programs and seeing where we may have generated unrealizable fiscal challenges, this 30 year look has reinvigorated the relationships and strengthened the ties between the S&T community and their PEO partners. We have had significant engagements over these past seven months – working to identify technical opportunities and the potential insertion of new capabilities across this 30 year timeframe.

Goals and Commitments

There are some persistent (and challenging) areas in which the Army invests its S&T resources to ensure that we remain the most lethal and effective Army in the world. The challenges include the obvious (we need better force protection) to the less obvious (retrograde). All are consistent, however, with the message that we have gotten from the Training and Doctrine Command over the past decade. These are challenges that remain ever relevant to the Army and its ability to win the fight. The S&T community is committed to addressing these challenges which include:

- Enabling greater *force protection* for Soldiers, air and ground platforms, and bases (e.g., lighter and stronger body armor, helmets, pelvic protection, enhanced vehicle survivability, integrated base protection)
- *Ease overburdened* Soldiers in small units (e.g., lighter weight multi-functional material)
- Enabling *timely mission command and tactical intelligence* to provide situation awareness and communications in ALL environments (mountainous, forested, desert, urban, jamming, etc.)
- *Reduce logistic burden* of storing, transporting, distributing and retrograde of materials
- Create operational overmatch (*enhance lethality and accuracy*)

- Achieve *operational maneuverability* in all environments and at high operational tempo (e.g., greater mobility, greater range, ability to operate in high/hot environment)
- Enable *ability to operate in* Chemical, Biological, Radiological, Nuclear, and Explosives (CBNRE) environment
- Enable *early detection and treatment for* Traumatic Brain Injury (TBI) and Post Traumatic Stress Disorder (PTSD)
- *Improve operational energy* (e.g., power management, micro-grids, increased fuel efficiency engines, higher efficiency generators, etc.)
- Improve *individual and team training* (e.g., live-virtual-constructive training)
- *Reduce lifecycle cost* of future Army capabilities

In addition, to these enduring challenges, the S&T community conducts research and technology that impacts our ability to maintain an agile and every ready force. This includes efforts such as establishing environmentally compatible installations and materiel without compromising readiness or training, leader selection methodologies, new test tools that can save resources and reduce test time and methods and measures to improve Soldier/unit readiness and resilience.

S&T Portfolio highlights

To be able to address the needs of the Army of the future, the S&T Enterprise must maintain a balanced investment - one that ensures the growth and development of innovative S&Es and the pursuit of critical technology that will ensure the Army remains preeminent in the world. Currently the portfolio includes about 20% in far-term, basic research for discovery and understanding of phenomena; 40% in mid-term, applied research for laboratory concept demonstrations (proof of concept); and 40% in near-term, advanced technology demonstrations of subsystems and components in a relevant environment (experimentation).

Our S&T program request for BA1-3 for FY2014 is \$2.205 billion - a 0.2% decrease from our FY2013 request. BA3 programs decrease by \$8.6 million, BA1 programs decrease by \$7.3 million and BA2 programs increase by \$11.2 million.

In FY2014 the Army is placing increased emphasis in research areas to support the Army's role in the National Military Strategy, such as vulnerability assessments, Anti-Access/Area Denial (A2/AD) technologies and long range fires. We are mindful however that the Army will continue to be called on for missions around the globe. The Army is currently deployed in ~160 countries conducting missions that range from humanitarian support to stability operations to major theater warfare.

The efforts of the S&T Enterprise are managed by portfolio to ensure maximum synergy of efforts and reduction of unnecessary duplication. There are currently six portfolios. Three are platform specific portfolios: Soldier, Ground, Air; the other three are enabling technology portfolios: C3I, Innovation Enablers, and Basic Research. Each affords the Army with unique capability. To facilitate this broad spectrum of capabilities, we are creating a culture of affordability and from a technology perspective have increased our focus on reducing lifecycle costs.

Soldier Portfolio

The Soldier portfolio is broad in nature – it extends from research in enhancing Soldier performance to improved Soldier equipment to new medical treatments. This portfolio touches all of the challenges listed above in some capacity. Focus areas include achieving technical advances based on future threats and environments in force protection, lethality, mobility, leader development, training, combat casualty care and rehabilitation medicine, as well as psychological and physical health treatments. In FY2014 we are requesting \$376.7 million for our Soldier portfolio.

The efforts in this portfolio are designed to address future threat environments while maximizing the effectiveness of Squad performance as a collective

formation. They result in state of the art changes to equipment and training tools and inform changes to policies, personnel selection and classification, and individual and collective training.

Major initiatives include the integration of lethality assets, individual protection, and dismounted soldier power. In the coming years, improving mission performance in a complex and dynamic environment will rely on improving the integration of cognitive and physical performance with emerging technology solutions leading to the advancements necessary to reduce the Soldier's load. Successful recent efforts include a collaborative effort with PEO Soldier to improve the form and fit of the Improved Outer Tactical Vest (IOTV) for female Soldiers. The existing IOTV designs were cut for a standard male and impeded the ability for female Soldiers to operate weapons and equipment effectively. The S&T community assessed the needs of the female Soldiers and as a result developed better waist and torso adjustment straps and less bulky collar and throat protection.

In keeping with our holistic approach to Army challenges, research will address the entire chain of services and technologies which touch our Soldiers and Squads from pre-deployment to mission capabilities needed on the battlefield to their return to civilian life. Pre-deployment and return to civilian life research includes important areas such as Post Traumatic Stress Disorder (PTSD) and Traumatic Brain Injury (TBI) which continue to be a source of serious concern. The U.S. Army Medical Research and Materiel Command (MRMC) has ongoing efforts to address these devastating conditions. Basic research efforts include furthering our understanding of cell death signals and neuroprotection mechanisms, as well as identifying critical thresholds for secondary injury comprising TBI. When cells die they release signals in the form of proteins. These proteins can be measured using different biological assays, which can tell you what type of response a cell has mounted against different types of injuries to include TBI, so you can quantify the level of injury.

We are also focused on investigating selective brain cooling and other non-traditional therapies for TBI, and identifying "combination" therapeutics that substantially mitigate or reduce TBI-induced brain damage and seizures for advanced development and clinical trials. We have had some recent successes in this area, including completion of a Food and Drug Administration effectiveness study on a candidate neuroprotective drug for treatment of TBI and completion of a pivotal trial for a bench-top assay for use in hospitals for the detection of TBI.

Research in the area of personnel selection, classification and training must also be looked at in light of future threats and evolving mission scenarios such as cyber and robotic interactions. Technologies which support future mission capabilities needed on the battlefield include efforts to reduce chronic conditions which may result from load-related injuries. Material and equipment design efforts focus on innovative decision and mission planning tools and the integration of individual and squad weapons, weapon sights, munitions and fire control while mitigating cognitive and physical burden on the increasingly complex battlefield. Finally, we are working on new materials and modular armor designs to optimize individual protective equipment to fully consider survivability in relation to mobility, lethality, and other aspects of human performance. This work is aligned with PEO Soldier's planned Soldier Protection Systems PoR which affords many opportunities for technology transition out of the S&T community.

Ground Portfolio

The Ground portfolio includes technologies for medium and long range munitions and missiles; directed energy weapons; combat and tactical vehicle; unmanned ground systems; countermine and counter Improvised Explosive Devices (IED) detection and neutralization; and base protection technologies. As with the Soldier portfolio, the ground portfolio addresses a number of the Army's enduring challenges including force protection, improved mobility and overmatch,

increased operational energy and reduced life cycle costs. In FY2014 we are requesting \$607.1 million for our Ground Portfolio

The Ground Portfolio has shifted to focus on developing A2/AD through Long Range Fires and Counter Unmanned Aircraft technologies. S&T is focusing on advanced seeker technologies to enable acquisition of low signature threats at extended ranges, along with dual pulse solid rocket motor propulsion to provide longer range rockets and extend the protected areas of air defense systems. We also continue to develop Solid State High Energy Lasers to provide low cost defeat of rockets, artillery, mortars and unmanned aircraft.

Also as part of A2/AD, we have increased funding for evaluation of austere ports of entry and infrastructure to better enable our ability to enter areas of conflict. We are maintaining technology investments in detection and neutralization of mines and improvised explosive devices to ensure freedom of maneuver.

In the past, we have designed vehicles with little consideration for accommodating Soldiers who have to operate in them. Now we are beginning to explore ways to design vehicles around Soldiers. Increasing protection levels of the platforms means impacting interior volumes reducing mobility, maneuverability, and freedom of movement for occupants, and leads to heavier platforms. The ongoing Occupant Centric Survivability (OCS) effort provides the mechanism to develop, design, demonstrate, and document an occupant centered Army ground vehicle design philosophy that improves vehicle survivability, as well as force protection, by mitigating Warfighter injury due to underbody IED and mine blast, vehicle rollover, and vehicle crash events. This design philosophy considers the Warfighter first, integrates occupant protection technologies, and builds the vehicle to surround and support the Warfighter and the Warfighter's mission. To this end, we are developing an OCS concept design demonstrator, as well as, platform-specific demonstrators with unique occupant protection technologies tailored to the platform design constraints. Subsystems and components designed and evaluated by this effort may transition to current and future ground vehicle Programs of Record. This focused effort will facilitate

the development and publication of standards for occupant centric design guidelines, test procedures and safety specifications.

Armor remains an Army-unique challenge and we have persistent investments for combat and tactical vehicle armor, focusing not only on protection but affordability and weight. We continue to invest in armor technologies to meet the Ground Combat Vehicle (GCV)'s objective protection requirements. Armor formulations developed at the Army Research Lab (ARL) and matured at the Tank Automotive Research Development and Engineering Command (TARDEC) have transitioned and been offered to the GCV vendors. In addition to the continued emphasis on lighter, more capable armor solutions, we are beginning to develop an architecture standard to enable the integration of active protection technologies onto ground vehicles, reducing the need for as much heavy armor plating.

We continue to develop technologies to increase available power to ground vehicles and improve fuel efficiency. Additionally, we are maturing architecture standards to manage electrical power and data, providing industry a standard interface for integrating communications and sensor components to ground vehicles.

Air Portfolio

The Army is the lead service for rotorcraft, owning and operating over 80% of the Department of Defense's vertical lift aircraft. As such, the preponderance of rotorcraft technology research and development takes place within the Army. The Air portfolio addresses many of the same challenges as the ground portfolio and its key initiative, the JMR TD program, is focused on addressing the A2/AD need for longer range and more effective combat profiles. Our vision for Army aviation S&T is to provide the best possible aviation technology enabled capabilities to deliver Soldiers, weapons, supplies and equipment where they are needed, when they are needed. For FY2014 we are requesting \$162.6 million for our Air Portfolio.

In order to provide Soldier support over future Areas of Operation (AO) that may be sixteen times larger than current AOs, the Army needs a faster, more efficient rotorcraft, with significantly improved survivability against current and future threats. Operating in conditions of 6000 feet and 95 degrees (high/hot), this aircraft will need to transport and supply troops while providing close air support and intelligence, surveillance and reconnaissance capabilities.

As I mentioned before, a major effort currently underway within S&T is technology development for the Department of Defense's next potential "clean sheet" design rotorcraft - the JMR aircraft. Three different configurations of JMR aircraft have been designed - a conventional helicopter, a large-wing slowed rotor compound helicopter, and a tilt rotor helicopter. We are investigating various design excursions to fully explore the size and environmental characteristics of interest to the DoD including shipboard operations. As part of the JMR TD program, an industry/government Configuration Trades and Analysis (CT&A) effort (including Operations Analyses to assess concept effectiveness), is nearing completion. Four contracts were competitively awarded to assist in defining the trade space for Phase 1 of the JMR TD, Air Vehicle Demonstration. Two of the contractors will be downselected for the Phase 1 awards in September 2013, which will include the design, fabrication, and test of two flight demonstrator vehicles, with first flights to occur in 4Q FY17. The JMR TD objectives are to validate critical aircraft configurations, technologies and designs at the vehicle system level, and demonstrate vertical lift capabilities superior to those in the current fleet. Phase 2 of the JMR TD is focused on assessing Mission Systems Effectiveness. Six contracts have been awarded to conduct these trades. The overall JMR TD effort will use integrated government/industry platform design teams and exercise agile prototyping approaches.

One of the biggest causes of aircraft loss comes from accidents while operating in a Degraded Visual Environments (DVE). To address this, we are currently conducting a synchronized, collaborative effort with PEO Aviation and the S&T community to define control system, cueing, and pilotage sensor combinations which enable maximum operational mitigation of DVE. This effort will result in a

prioritized list of compatible, affordable DVE mitigation technologies, and operational specification development that will help inform future Army decisions. This program is tightly coupled with the PEO Aviation strategy and potential technology off-ramps will be transitioned to the acquisition community along the way, when feasible.

Unmanned systems have a potentially broad impact on how the Army conducts close air support. Army S&T is focused on improving the capability of unmanned systems to be a force multiplier through the introduction of unmanned and teaming operations technologies with the potential to offer game changing future capabilities. Efforts include advancing human systems interface and algorithms for synergistic and intelligent manned unmanned teaming, and image/data processing algorithms to allow objective driven perception. In FY14 we plan to initiate a new applied research program to develop micro/small scale unmanned air systems. This new effort will allow for the transition of technology from the Micro-Autonomous Systems Technology Collaborative Technology Alliance basic research effort.

While many of our rotorcraft research efforts are focused on the development of technology for transition to new platforms in 2025 and beyond, we are also maintaining an investment to keep the current fleet effective. One recent transition success has been the Advanced Affordable Turbine Engine (AATE), a 3000 shaft horsepower engine with 25% improved fuel efficiency, and 35% reduced lifecycle costs. In FY2013, final bench testing will be completed and the AATE program will transition to PM Utility for Engineering and Manufacturing Development under the Improved Turbine Engine Program, which will re-engine our Blackhawk and Apache fleet.

C3I Portfolio

The C3I portfolio provides enabling capability across many of the challenges, but specifically seeks to provide mission command and tactical intelligence -- working to ensure Soldiers from the sustaining base to the tactical edge have trusted and responsive sensors, communications, and information adaptable in

dynamic, austere environments to support battlefield operations and non-kinetic warfare. For FY2014 we are requesting \$320.0 million for our C3I Portfolio.

New efforts in this portfolio include development of secure wireless personal area networks for the Soldier. We are also re-investing in Electronic Warfare (EW) vulnerability analysis to perform characterization and analysis of radio frequency devices to develop detection and characterization techniques, tactics, and technologies to mitigate the effects of contested environments (such as jamming) on Army C4ISR systems.

Given the potential challenges that we face while operating in a more contested environment, we are placing additional emphasis in assured Position, Navigation and Timing, developing technologies that allow navigation in Global Positioning System (GPS) denied/degraded environments for mounted and dismounted Soldiers and unmanned vehicles such as exploiting signals of opportunity. Improvements will be studied for high sensitivity GPS receivers that could allow acquisition and tracking under triple tree canopy, in urban locations, and inside buildings, which is not currently possible. We are developing an Anti-Jam capability as well as supporting mission command with interference source detection, measurement of signal strength, and locating interference sources, enabling the Army to conduct its mission in challenging electromagnetic environments.

The C3I Portfolio also houses our efforts in cyber, both defensive and offensive. Defensive efforts in cyber security will investigate and develop software, algorithms and devices to protect wireless tactical networks against computer network attacks. Effort includes technologies that are proactive rather than reactive in countering attacks against tactical military networks.

We are developing sophisticated software assurance algorithms to differentiate between stealthy life cycle attacks and software coding errors and design and assess secure coding methodologies that can detect and self correct against malicious code insertion. We are also investigating theoretical techniques for improvements in malware detection that can detect malware variants

incorporating polymorphic and metamorphic transformation engines. We will research and design sophisticated, optimized cyber maneuver capabilities that incorporate the use of reasoning, intuition, and perception while determining the optimal scenario on when to maneuver, as well as the ability to map and manage the network to determine probable attack paths and the likelihood of exploitation. Additionally we will investigate dynamically and efficiently altering tactical network services, ports, protocols and systems to inhibit red force ability to perform malicious network reconnaissance to determine location of critical networking services.

On the offensive side of cyber operations, we will develop integrated electronic attack (EA) and computer network operations (CNO) hardware and software to execute force protection, EA, electronic surveillance (ES) and signals intelligence (SIGINT) missions in a dynamic, distributed and coordinated fashion, resulting in the capability to engage a multitude of diverse multi-node, multi-waveform, multi-platform and cyber (internetworked computers) targets while maximizing overall network efficiency and effectiveness, and preserving blue force/non-combatant communications.

We will demonstrate protocol exploitation software and techniques that allow users to remotely coordinate, plan, control and manage tactical EW and Cyber assets; develop techniques to exploit protocols of threat devices not conventionally viewed as Cyber to expand total situational awareness by providing access to and control of adversary electronic devices in an area of operations.

Innovation Enablers

The Innovation Enablers portfolio includes many of the activities that are not directly tied to programs of record, yet enable the Army to be successful. It is within this portfolio that we conduct the research that helps to ensure that we have training ranges upon which our Soldiers can train as they fight, support our High Performance Computing Centers which facilitate highly complex research and system design, and conduct Technology Maturation Initiatives that partner

the S&T community directly with PEOs to conduct experimentation that not only informs realistic requirements but also drives down programmatic risk. For FY2014 we are requesting \$302.0 million for our Innovation Enablers Portfolio.

Under this portfolio we focus on many of those technologies which, while not specific to warfighter functions, are essential to ensuring that Warfighters can conduct their missions. As the largest land-owner/user within the DoD, it is incumbent upon the Army to be good stewards in their protection of the environment. Within this portfolio, we develop and validate lifecycle models for sustainable facilities; create dynamic resource planning/management tools for contingency basing;; develop decision tools for infrastructure protection and resiliency; and assess the impact of sustainable materials/systems. This includes the development of geo-environmental intelligence /advanced sensing capabilities and predictive computational tools for fate, transport and effects of existing and emerging chemicals and materials used by the Army as well as new formulations for munitions and obscurants that have minimal environmental impacts. We also focus on developing sustainable and environmentally friendly practices that not only reduce or eliminate Soldier exposure to hazardous and carcinogenic materials but also minimize environmental impacts during maintenance and depot activities such as painting and plating.

In addition, we conduct blast noise assessment and develop mitigation technologies to ensure that we remain "good neighbors" within Army communities and work to protect endangered species while we ensure that the Army mission can continue. Ensuring current and future use of the Army's training ranges will become even more important as they will be where Soldiers get their experience, vice deployment in theater. As a result, we are even developing planning and response tools to determine impacts on mission critical natural infrastructure and adaptable training land configuration technologies to ensure our Soldiers are given maximum access to training ranges and lands. This supports the Army's ability to address evolving mission requirements while protecting our current resources.

Basic Research

Underpinning all of our efforts and impacting all of the enduring Army challenges is a strong basic research program. The vision for Army basic research is to advance the frontiers of fundamental science and technology and drive long-term, game-changing capabilities for the Army through a multi-disciplinary portfolio teaming our in-house researchers with the global academic community. For FY2014 we are requesting \$436.7 million for Basic Research.

Two high pay-off areas of research investment are Neuroscience and Materials Science. Neuroscience is a high priority research area -- understanding the brain's structure and function is a top foundational research theme for the Obama Administration and the National Academies. The Army is leveraging the opportunities afforded by the large medical research base in neuroscience to move neuroscience from the bench to the battlefield. Making this transition will enable a broad range of scientific discoveries that fundamentally shift how we understand how the brain (and thus Soldiers) works.

A new area of promising research is our effort in Multi-scale Modeling of Materials. The goal of this research is to realize the capability to design materials at the atomic level to provide the exact properties we need for an end product. In other words, we plan to demonstrate a comprehensive "materials by design" capability for electronic and protection materials. The pay-off could be protection materials with 1/3 savings in weight of current systems, and batteries with triple the energy density, 30 percent longer lifetimes, and 20-30 percent more efficiency all at a lower cost.

Another new area of basic research investment in FY14 is Cyber Security, where we are standing up a Cyber Security Collaborative Research Alliance (CRA), a competitively selected consortium, to advance the theoretical foundations of cyber science in the context of Army networks. This CRA consists of academia, industry and government researchers working jointly with the objective of developing a fundamental understanding of cyber phenomena so that laws, theories, and theoretically grounded and empirically validated models can be

applied to a broad range of Army domains, applications, and environments. The overarching goals of cyber security are to significantly decrease the adversary's return on investment when considering cyber attack on Army networks, and minimizing the impact on Army network performance related to implementing cyber security. The CRA research creates a framework that effectively integrates the knowledge of cyber assets and potential adversary capabilities and approaches, and provides defense mechanisms that dynamically adjust to changes related to mission, assets, vulnerability state, and defense mechanisms.

We had a number of technology spin-offs and transitions from basic research this past year. An example is in Helmet Mounted Displays. A researcher from the Institute for Creative Technologies, an Army funded University Affiliated Research Center, created a game-changer in the world of virtual reality (VR) headsets by providing a 3-D, wide field of view, tracking enabled VR headset at a cost of \$300 (in contrast to an Army Helmet Mounted Display device that costs \$70,000). The VR device called Oculus Rift won Wired Magazine's best of the Consumer Electronics Show (CES) 2013 and the Electronic Entertainment Expo (E3) best of award. Oculus Rift disrupts the supply chain and creates the option for a low cost tool developed by Army-sponsored research that the Army will leverage for training. The hope is that the Oculus Rift will be the first of many commercial applications that will be incorporated into our Army systems - increasing competition and decreasing costs.

Cross-Portfolio Activities

Across all of our portfolios, we maintain our focus on power and energy. As we develop technology enabled capabilities, we work to reduce the burden in both weight and logistics that comes from increased energy consumption by the increasing amount of electronic equipment we need in our operations. The Army modernization investment in operational energy provides efficient, reliable and maintainable systems that increase capabilities and maintain dominance. Our objectives are to improve efficiency and reduce consumption while increasing functionality and developing smart energy-saving designs. Our existing

programs are integrated with, and complementary to, the operational energy strategy of the Assistant Secretary of the Army for Installations, Energy and the Environment. In the FY2014 Budget Request we have, interspersed among our portfolios, \$145.3 million for power and energy projects, in addition to efforts such as efficient vehicle design and light weight materials which also impact the Army's energy usage.

The Army continues to make use of the Rapid Innovation Fund, established by Congress in FY 2011. We are currently funding 48 efforts in a variety of areas and have an additional 43 proposals under review. I believe that this initiative is providing value to the Army and opening up more collaborative opportunities for small and non-traditional businesses, and we plan to solicit further proposals for FY 2013 in the near future.

The Army Small Business Innovation Research Program (SBIR) program is another way the Army gets access to innovative ideas and products. The SBIR program is designed to provide small, high-tech businesses the opportunity to propose innovative research and development solutions in response to critical Army needs. In FY11, the Army SBIR office generated 139 topics based on inputs from laboratories, the Army Training and Doctrine Command and the Program Executive Officers (PEO). In response to these topics, small businesses submitted over 3000 proposals. The Army SBIR office approved more than 600 Phase I and Phase II awards. Since 2000 there have been 575 Phase III Army SBIR projects put under contract for a total obligated value of \$1.4 billion (Phase III SBIRs are Phase II projects that have been picked up by either the government (PEO/PM) or industry).

The S&T Enterprise Workforce

Without the world-class cadre of over 12,000 scientists and engineers and the infrastructure that supports their work, the Army S&T enterprise would be unable to support the needs of the Army. To maintain technological superiority now and in the future, the Army must maintain an agile workforce. Despite this current environment of unease within the government civilian workforce, I'm proud to say

that in 2012, the Army was recognized by Thompson Reuters as one of the Top100 Global Innovators, with over 300 patents documented in the previous three years. We have an exceptional workforce. But we must continue to attract and retain the best science and engineering talent into the Army Laboratories and Centers and this is becoming more and more challenging. Our laboratory personnel demonstrations give us the flexibility to enhance recruiting and afford the opportunity to reshape our workforce, and I appreciate Congress' continued support for these authorities. With one exception (the Army Research Institute (ARI) for the Behavioral and Social Sciences), all of our laboratories and centers are operating under this program (ARI was never designated a Science and Technology Reinvention Laboratory and given its small size, has not sought to enter into a demo system). These initiatives are unique to each laboratory, allowing the maximum management flexibility for the laboratory directors to shape their workforce and remain competitive with the private sector.

In terms of infrastructure, we completed a survey of our laboratory infrastructure and find that it is aging, with an average approximate age of 50 years. However, we do acknowledge that much of the Army is in a similar position. Despite this, we continue to make improvements to our infrastructure at the margins, and where possible we have used MILCON, through your generous support, Defense Base Realignment and Closure Commission (BRAC), and unspecified minor construction to modernize facilities and infrastructure. This is not a long-term solution. While the authorities that you have given us have been helpful, they alone are not enough, and we are still faced with the difficulty of competing within the Army for scarce military construction dollars at the levels needed to properly maintain world-class research facilities. This will be one of our major challenges in the years to come and I look forward to working with OSD and Congress to find a solution to this issue.

Army S&T enterprise cannot survive without developing the next generation of scientists and engineers. We are lucky to have an amazing group of young scientists and engineers to serve as role models for the next generation. Last year, Dr. Maria Urso, a researcher at the U.S. Army Research Institute of

Environmental Medicine's Military Performance Division at Natick Soldier System's Center in Natick, Massachusetts, was named by President Obama as one of the nation's Outstanding Early Career Scientists. She received the award for her scientific contributions in the area of cellular mechanisms of musculoskeletal injury and repair and for her incredible service to both military and civilian communities. The Presidential Early Career Awards for Scientists and Engineers are the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent research careers, and we are lucky to have researchers like Dr. Urso to mentor the next generation.

The Army S&T Enterprise contributes to the future success in Science, Technology, Engineering and Math (STEM) education through the Army Educational Outreach Program (AEOP) which is comprised of 17 outreach efforts, either through direct oversight or through active participation. In the 2011-2012 academic year AEOP was able to place less than half of the student online applicants, engaged nearly 53,000 students as well as 835 teachers, involved 17 Army laboratories or installations, and 111 universities or colleges and utilized the experience and personal commitment from many of our Army scientists and engineers. Mostly executed under the Army Educational Cooperative Agreement (COA) which brings together government and a consortium of organizations working collaboratively to further STEM education and outreach efforts nationwide, AEOP provides a cohesive and coordinated approach to STEM education across the Army. Major accomplishments in FY 12 included ongoing annual in-depth evaluative assessments of 7 programs and recommendations for evidence-based program improvements. We completed a marketing campaign that centralized all the individual programs into a single branding to leverage resources as well as promote a continuation of Army STEM experiences that work together to build a highly competitive STEM literate talent pool for Army scholarship and workforce initiatives. We continue to enhance the online, comprehensive application tool located on the AEOP website which will be complete in FY13. The application tool will provide important data that assess

attitudes, motivation, qualifications, and experiences that gauge program effectiveness. The website and the online application tool as well as the COA will work together to provide a coherent and coordinated approach to address the STEM workforce shortfall throughout the Army. For FY2014, we are concentrating on further program assessment, implementing evidence-based program improvements, strengthening additional joint service sponsored efforts, and identifying ways to expand the reach and influence of successful existing programs by leveraging partnerships and resources with other agencies, industry and academia.

Finally, we are increasingly mindful of the globalization of S&T capabilities and expertise. Our International S&T strategy provides a framework to leverage cutting edge foreign science and technology enabled capabilities through Global S&T Watch, engagement with allies and leadership initiatives. Global Science and Technology Watch is a systematic process for identifying, assessing, and documenting relevant foreign research and technology developments. The Research, Development and Engineering Command's (RDECOM) International Technology Centers (ITCs) and Medical Research Materiel Command's OCONUS laboratories identify and document relevant foreign S&T developments. We also selectively engage our allies when their technologies and materiel developments can contribute to Army needs and facilitate coalition interoperability. These bilateral leadership forums with Israel, Canada, Germany and the United Kingdom provide both visibility of and management decisions on allied developments that merit follow-up for possible collaboration.

Summary

The underpinning all of Army S&T efforts is a strong research program that builds an agile and adaptive workforce and technology base to be able to respond to future threats. Investments in S&T are a critical hedge in acquiring technological superiority with revolutionary and paradigm-shifting technologies. This includes the development of the next generation of Army Scientists and Engineers.

Investing wisely in people with innovative ideas is our best hope for new discoveries to enable the "Army of the Future."

In this fiscally constrained environment, we will emphasize S&T areas that address truly Army-unique challenges and leverage everything else. We will collaborate across the Services, National Labs, academia, industry and partner Nations, to solve common challenges. As good stewards of the taxpayers' dollars, it is critical that we use finite government resources to maximize development of technologies to meet Army-unique challenges and constraints, and it is important that we complement what the private sector is already developing. Most importantly, our investments today must translate into capabilities we successfully field to the Army of the future.

As the ASA(ALT) said in her February 28, 2013 testimony to the House Armed Services Committee on Sequestration, "...the Army will provide Soldiers with the best equipment available as needed; their sacrifice deserves no less. All equipping programs and priorities will be negatively affected by the application of sequestration. Likewise the defense industrial base will be adversely impacted and critical skill sets will be lost." These words apply equally to the Army's S&T program – forcing us to take a hard look at our investments and undoing much of the work that we have set in place to increase our efficiencies.

This is an interesting, yet challenging, time to be in the Army. Despite this, we remain an Army that is looking towards the future while taking care of the Soldiers today. I hope that we can continue to count on your support as we move forward, and I would like to again thank the members of the Committee again for all you do for our Soldiers. I would be happy to take any questions you have.



Biography

Department of the Army



Ms. Mary J. Miller
Deputy Assistant Secretary of the Army
(Research and Technology)



Ms. Miller was selected for the Senior Executive Service in August of 2005. In February of 2013, she was designated as the Deputy Assistant Secretary of the Army for Research and Technology. Ms. Miller is responsible for the entirety of the Army's Research and Technology program, spanning 16 Laboratories and Research, Development and Engineering Centers, with more than 12,000 scientists and engineers and a yearly budget of just over \$2 billion dedicated to empowering, unburdening and protecting Soldiers.

CAREER CHRONOLOGY:

- Feb 2013 – Present: Deputy Assistant Secretary of the Army (Research and Technology)
- Sep 2012 – Feb 2013: Acting Deputy Assistant Secretary of the Army (Research and Technology)
- Dec 2010 – Sep 2012: Deputy Program Executive Officer Soldier
- Aug 2005 – Dec 2010: Director for Technology, Office of the Assistant Secretary of the Army for Acquisition, Logistics and Technology, Pentagon, Washington, D.C.
- Apr 2001 - Aug 2005: Deputy Director of Technology for Aviation, Missiles, Soldier and Precision Strike under the Director for Technology, OASA(ALT), Pentagon, Washington, D.C.
- Oct 1992 - Apr 2001: Team Leader Nonlinear Optical Processes Team, U.S. Army Research Laboratory (ARL), Adelphi, MD
- Jun 1999 - Jun 2000: Science and Technology Liaison to the Deputy Chief of Staff for Operations – Force Development (now the DCS G8-FD). Pentagon, Washington, D.C.
- Mar 1990 – Oct 1992: Team Leader, Advanced Optics Team, Project Lead for the Visible/Near Infrared (VIS/NIR) Sensor Protection efforts, Night Vision & Electro-Optics Directorate, Laser Division, Ft. Belvoir, VA
- Jul 1984 – Mar 1990: Electronics Engineer, Night Vision & Electro-Optics Directorate, Laser Division, Ft. Belvoir, VA

COLLEGE:

- Masters of Business Administration from the University of Tennessee, Knoxville, TN.
- Masters of Science in Electrical Engineering, Electro-Physics from the George Washington University, Washington, D.C.
- Bachelor of Science in Electrical Engineering from the University of Washington, Seattle, WA.

AWARDS AND HONORS:

- Army Research & Development Achievement Award in 1988 for her technical achievement in the "Development of Nonlinear Materials for Sensor Protection."
- Four patents awarded for sensor protection designs, two additional patents pending.

CERTIFICATIONS:

- Certified Level III in Program Management
- Certified Level III SPRDE, Systems Engineering
- Certified Level II SPRDE, Program Systems Engineering

PROFESSIONAL MEMBERSHIPS AND ASSOCIATIONS:

- Association of the United States Army (AUSA), member since 2003

MAJOR PUBLICATIONS:

Ms. Miller has published more than 50 papers and has addressed over 30 major commands and international groups with technical presentations. She served as a conference committee member and co-chair for SPIE Conference on Nonlinear Optical Liquids, 1996-1998 and served as a peer-reviewer for technical papers in her area of specialty submitted to the Journal of Applied Optics, Applied Optics and Optics Letters from 1987-1999.

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March 2013

NOT FOR PUBLICATION UNTIL RELEASED BY THE
HOUSE ARMED SERVICES COMMITTEE
INTELLIGENCE, EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
REAR ADMIRAL MATTHEW L. KLUNDER, UNITED STATES NAVY
CHIEF OF NAVAL RESEARCH

BEFORE THE
INTELLIGENCE, EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2014 BUDGET REQUEST

APRIL 16, 2013

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EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

Introduction

It is an honor to appear before the subcommittee to report on Department of the Navy (DoN) Science and Technology (S&T) and discuss how the President's FY 2014 Budget supports the Navy and Marine Corps (USMC). The President's FY 2014 Budget requests approximately \$2 billion for Naval S&T.

For over 200 years, the Navy and Marine Corps have used S&T to provide technological superiority to enable the defense of U.S. interests. After World War II, congress established the Office of Naval Research (ONR) to "plan, foster and encourage scientific research in recognition of its paramount importance to future Naval power and national security." Our S&T objective is to support a Navy and Marine Corps that can prevail in any environment. We work directly with the Secretary of the Navy (SECNAV), Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC) to strike a balance between near-term technology development and long-term research. As we implement CNO and CMC guidance in application of S&T resources, we constantly strive to improve system affordability, communication with the acquisition community, and constructive engagement with all of our stakeholders.

Science and Technology Strategic Plan

The Naval S&T Strategic Plan was developed to guide our investments and is regularly reviewed by Navy and USMC leadership to affirm the alignment of Naval S&T with current missions and future requirements. It ensures S&T has long-term focus, meets near-term objectives, and makes what we are doing clear to decision makers, S&T partners, customers and performers.

The Strategic Plan identifies nine focus areas where S&T investments support Navy and USMC requirements: 1) Assure Access to Maritime Battlespace, 2) Autonomy and Unmanned Systems, 3) Expeditionary and Irregular Warfare, 4) Information Dominance, 5) Platform Design and Survivability, 6) Power and Energy, 7) Power Projection and Integrated Defense, 8) Total Ownership Cost, and 9) Warfighter Performance.

Our goal is to move from existing systems and concepts of operations toward a warfighting capability to counter predicted threats in an increasingly complex and uncertain environment. The proliferation of anti-access, area-denial (A2/AD) capabilities among potential adversaries drives the need for technologies that assure access for Naval forces. One of our greatest challenges is to defeat A2/AD threats which essentially compel us to respond to \$50K threats with \$3M weapons. We must get on the right side of this equation – and have weapons in development that will allow us to achieve that asymmetric cost advantage currently held by some of our adversaries. Beginning with the evolution of current systems through incremental improvement and spiral development of known technology, we strive to move toward development of undiscovered, disruptive, game-changing technologies, particularly as we recognize the strategic relevance to the Pacific and Middle East.

Implementing the Strategy

We execute Basic Research (6.1) thru Advanced Technology Development (6.3) funds by dividing S&T into four primary areas – Discovery and Invention (D&I), Leap Ahead Innovations (Innovative Naval Prototypes), Acquisition Enablers (Future Naval Capabilities), and a Quick Reaction capability to respond to emerging requirements. Our portfolio balances a range of complementary but competing initiatives: while we support advances in established operational areas – we maintain a far-reaching complement of long-term research that may prove disruptive to traditional operational concepts.

Discovery and Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements essential to Naval missions, as well as in areas that are undefined but hold promise for future application. D&I develops fundamental knowledge, provides a basis for future Navy/Marine Corps systems, sustains our Scientist/Engineer workforce, and has led to over 60 Nobel Prizes for ONR researchers – the most recent being Dr. David Wineland, who received the Nobel Prize in Physics in 2012. D&I is the foundation for advanced technology.

Approximately 45 percent of ONR investments are in D&I. We invest resources in the best research areas and projects to develop a broad base of scientific knowledge from which INP, FNC, and quick reaction efforts are generated. Approximately 60 percent of basic research is executed with academic and non-profit performers, with programs peer reviewed by outside scientific and technical experts who provide an independent assessment of the scientific merit of the research being conducted. Results are reviewed by ONR program officers, division directors, department heads and senior leadership. Risk, impact, significance, originality, scientific merit, principal investigator, and budget resources are evaluated.

The best recent example of direct links between D&I and advanced technology was reported in early March of this year, when a pioneering atomic theory involving quantum mechanics barely imagined early in the last century was verified through current ONR research investments. A team of scientists from Massachusetts Institute of Technology and the University of California at Berkley demonstrated that while the positive charge of an atomic nucleus and negative charge of the surrounding electrons balance each other out to provide atomic stability, under certain conditions the electrons collapse into the nucleus. That phenomenon has been simulated and observed, with profound implications for our understanding of basic physics and chemistry. It has the potential to contribute to the improved design of nanotechnology devices, development of ultrafast transistors, and development of graphene-based electronic devices used in detection of trace chemicals and biomarkers. In addition to ONR, this research was sponsored by the Department of Energy, National Science Foundation, and the Engineering and Physical Sciences Research Council in the United Kingdom. It is not going too far out on a limb to suggest that this may result in yet another Nobel Prize awarded to ONR researchers.

ONR's University Research Initiative (URI) includes the Multidisciplinary University Research Initiative (MURI), the Defense University Research Implementation Program (DURIP), and the Presidential Early Career Award for Scientist and Engineers (PECASE). MURI supports teams of researchers investigating topics that intersect multiple technical disciplines in order to speed transition of basic research to practical applications. ONR awarded 14 MURI grants in FY2009,

12 in FY 2010, 11 in FY 2011, 9 in FY 2012, with 8 awards expected in FY 2013. DURIP supports research essential to the Navy through grants for the purchase of instrumentation necessary to perform cutting-edge research. PECASE identifies and honors the achievements of young scientists and engineers at the outset of their careers and encourages them to explore S&T professions in academia and Naval laboratories.

Other D&I initiatives include the Basic Research Challenge, which funds promising research not addressed by the current core program. ONR also sponsors the Young Investigator Program, which supports academic scientists and engineers who, early in their careers, show exceptional promise for doing Naval research. Education and research opportunities for undergraduate and graduate students, fellows, and future faculty members are provided through the Naval Research Enterprise Internship Program (NREIP), in which participants work at Naval laboratories and warfare centers. The In-House Laboratory Independent Research (ILIR) and Independent Applied Research (IAR) programs sponsor critical research, while furthering the education of scientists and engineers at Warfare Centers. Finally, ONR intends to strengthen our partnership with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI), which brings together Naval Laboratories and warfare centers with dozens of HBCU/MIs, giving hundreds of students an opportunity for hands-on experience in the Naval research environment.

Science, Technology, Engineering and Mathematics (STEM)

Our ability to support the warfighter depends on our ability to sustain a Science, Technology, Engineering and Mathematics (STEM) workforce – with D&I investments supporting STEM outreach from kindergarten through post-doctoral education. One of our greatest challenges involves our concern that the number of U.S. citizen STEM graduates will not keep up with future U.S. demand or with international competition for the same talent.

Navy's STEM program is intended to ensure a strong STEM workforce. As I testified last year, our S&T workforce is aging, with about 2/3 of Navy science and engineering professionals over age 40, and approximately 50% retirement eligible by 2020. Because Navy's S&E workforce is comprised mostly of engineers, we face a potentially staggering shortfall – particularly in Naval engineering, computer science and ocean engineering. Our production of engineers has been flat for two decades, and far less in these specialty fields. Complicating our challenge is the fact that DoN must rely on U.S. citizens for classified work.

Our investments seek to increase diversity and numbers of students pursuing STEM degrees. Areas of emphasis include: 1) freshman and sophomore STEM retention in college, 2) hands-on STEM programs in urban and rural middle schools, 3) teacher training in Naval-relevant fields of study, and 4) mission-critical graduate student and post-doctoral support. Programs incorporate Naval content, metrics to measure impact, and coordinate with other Federal STEM programs. Further, programs are selected based on potential for growth and geographic expansion, as well as ability to serve underrepresented student populations.

By the end of middle school, many students – particularly from underserved populations (minorities, females, those from urban and rural settings) decide to opt out of STEM education. It is critical to engage these students no later than middle school by offering a variety of hands-

on learning opportunities and mentoring experiences to build STEM confidence and encourage them to pursue the math and science classes needed to be STEM eligible in college.

This investment can only be justified if we are improving our workforce. For many investments we may not be able to see a return for years. However, we assess each investment to determine how it contributes to achieving Naval goals. We are in the process of developing a comprehensive metrics and evaluation plan for all STEM programs, which measures not only numbers of students and teachers, but assesses our ability to fulfill Naval requirements.

Leap Ahead Innovations (Innovative Naval Prototypes)

Innovative Naval Prototypes (INP) involve approximately 12 percent of the S&T budget. They focus on high-risk/high-payoff opportunities from the D&I portfolio that can significantly impact Naval capabilities if we can mature the technology. INPs are discontinuous, disruptive, radical departures from established requirements and operational concepts. Approved and overseen by the Naval Research, Development, Testing and Evaluation (RTD&E) Corporate Board (Undersecretary of the Navy; Assistant Secretary of the Navy for Research, Development and Acquisition; Vice Chief of Naval Operations; Assistant Commandant of the Marine Corps), the goal is to prove concepts and mature technology in four to eight years, allowing informed decisions about risk reduction and transition into acquisition programs. In order to facilitate transition to acquisition programs, Program Managers and Deputy Program Managers are primarily selected from ONR and the Acquisition community.

INPs include:

Electromagnetic Railgun is a revolutionary long range gun with multi-mission potential including ballistic and cruise missile defense, long range land attack, and anti-surface warfare against small boats and ships. Fired by an electric pulse, Railgun eliminates explosive gun propellant from ships' magazines resulting in greater resilience to battle damage. ONR has established a firm foundation for ongoing system development. Since 2005 the state of the art for launch energy has advanced by a factor of 5 (to 32 mega joules) providing the potential to launch lethal projectiles to ranges up to 110 nautical miles. Projectile design is underway including successful open range lethality testing, component development and extensive modeling and simulations. Barrel life has increased from tens of shots to over 400 with a path to 1000 shots. Contractor built advanced composite launchers have been strength tested to operational levels. Meanwhile, the physical size of the pulsed power system has been reduced by a factor of 2.5 through increased energy density so that the system will fit into current and future surface combatants. Current ONR research is focused on rep-rate capability of multiple rounds per minute which entails development of a tactical prototype gun barrel and pulsed power systems that incorporate advanced cooling techniques. These components are being designed to transition directly into prototype weapons systems currently being conceptualized. ONR is working closely with Naval Sea Systems Command (NAVSEA) and the Office of the Secretary of Defense (OSD) Strategic Capabilities Office to ensure maximum commonality and to reduce the need for expensive and time consuming redesign. Developmental testing is ongoing at Naval Surface Warfare Center, Dahlgren, Virginia as well as the Naval Research Laboratory (NRL). I invite you to visit either of these world class facilities.

Integrated Topside (InTop) will enable Navy to dominate the electromagnetic spectrum through development of multi-beam, multi-function ultra-wideband apertures and Radio Frequency (RF) equipment for all ship classes. We are developing advanced Electronic Warfare, Information Operations, Radar, Satellite and Line of Sight Communications using: 1) open architecture for RF equipment, plus computer hardware and software that will enable industry to contribute to development of affordable new systems and upgrades, and 2) modular systems that enable the same technology to be scalable across all Naval platforms and significantly reduce logistics, training, and maintenance costs. We continue prototype tests and demonstrations at facilities in Maryland, New Jersey, New York, Rhode Island, Texas, and the Naval Research Laboratory (NRL), with subsequent initial deliveries for commencement of testing by the Naval Undersea Warfare Center (NUWC) for submarine Satellite Communications (SATCOM) and by NRL for the Surface Electronic Warfare Improvement Program (SEWIP) Block 3 prototype.

The Large Displacement Unmanned Undersea Vehicle (LDUUV) is developing a reliable, long endurance UUV capable of extended operation in cluttered littoral environments. The program is developing the needed energy, autonomy and core UUV systems to operate in a complex ocean environment near harbors and high surface traffic locations. Key goals include doubling current UUV energy density, and using open architecture to lower costs, while enabling full autonomy in over the horizon operations. Achieving these goals will reduce platform vulnerability, while enhancing warfighter capability and closing gaps in critical mission areas. During FY 2013 sea trials, we will develop autonomous behaviors and demonstrate reliable battery and fuel cell power systems with a series of longer endurance tests.

The Autonomous Aerial Cargo/Utility System (AACUS) is developing intelligent, autonomous capabilities for rapid, affordable, and reliable rotorcraft supply in permissive, hostile and GPS-denied settings. AACUS-enabled aircraft will be supervised by field personnel with no special training from a handheld device. Challenges include dynamic mission management and contingency planning, as well as landing execution and obstacle avoidance under demanding conditions. AACUS is designed for open system architecture to promote modularity and affordability and could be used in Casualty Evacuation (CASEVAC), combat rescue, and humanitarian aid missions.

In addition to INPs, SwampWorks programs, although similarly high-risk and disruptive, are smaller than INPs and intended to produce results in 1 to 3 years. SwampWorks efforts have substantial flexibility in planning and execution, with a streamlined approval process. Although a formal transition agreement is not required, SwampWorks programs have advocates outside ONR, either from the acquisition community or Fleet/Force. SwampWorks products are frequently inserted into Fleet/Force experimentation and can provide impetus for new acquisition requirements.

Acquisition Enablers (Future Naval Capabilities)

Acquisition Enablers (AE) are the most critical component of our transition strategy. Most of the AE portfolio consists of our Future Naval Capabilities (FNC) program, with the remainder including USMC Advanced Technology Development (6.3) funds, Joint Non-Lethal Weapons

Directorate 6.3 funds, the Manufacturing Technology (ManTech) program, and Low Observable, Counter Low Observable funds.

FNCs are near-term projects, the requirements-driven, delivery-oriented portion of the S&T portfolio. FNCs deliver mature component technologies to acquisition sponsors to incorporate into systems that provide new warfighter capabilities. FNC investments use a collaborative process involving requirements, research, acquisition, and Fleet/Force communities to align the requirements-driven portion of the S&T portfolio with Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and Marine Corps Combat Development Command (MCCDC). A gap is any capability required to achieve Naval objectives that are not achievable with current platforms, weapon systems, doctrine, organizational structure, training, materials, leadership, personnel or facilities and requires S&T investment to solve or overcome. Capability Gaps define the requirement, not how to meet it.

FNC projects are selected annually to address specific gaps, with final prioritization approved by a 3-Star Technology Oversight Group (TOG) representing OPNAV, Marine Corps (USMC), U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy (ASN-RDA) and ONR. FNCs are based on D&I investments where technology can be matured from Technology Readiness Level (TRL) 3 to TRL 6 within three to five years. Selection takes account of related work in the Defense Department (DoD), government agencies, industry and Naval centers of excellence.

Approved technology products are required to have Technology Transition Agreements that document the commitment of the resource sponsor, acquisition program, and ONR to develop, deliver and integrate products into new or upgraded systems to be delivered to the Fleet/Force. Every FNC product is annually measured against technical and financial milestones. All FNC products must meet required transition commitment levels for S&T development to continue. This practice helps make every dollar count. Products that no longer have viable transition paths are terminated with residual funding used to solve problems with existing projects, or start new projects in compliance with Navy priorities, charters, business rules and development guidelines. The measure of FNC success is whether projects meet technology requirements and exit criteria, and whether acquisition sponsors have transition funds in their programs to accept and integrate FNC products. Products with planned transition funds usually transition after risks are mitigated, a definitive plan finalized, and required funding programmed.

Our investments focus on the most pressing capability gaps, with changes in funding for FNC products based on successful transitions, reprioritization, new starts, and evolving Naval needs. As FNC products mature, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. Year one is predominantly 6.2; the final year predominately 6.3 – with a mix of 6.2/6.3 between. As products transition to from S&T to Advanced Component Development and Prototypes (6.4) and Engineering and Manufacturing Development (6.5) funding, responsibility for continued development shifts from ONR to acquisition commands.

Quick Reaction S&T

ONR maintains a quick-reaction capability involving projects of 12 to 24 months duration that respond to immediate requirements identified by Fleet/Force or Naval leadership. TechSolutions provides short-term solutions to immediate operational and tactical requirements. Accessible via the Internet and SIPRnet, TechSolutions accepts recommendations from Sailors and Marines at a tactical level about ways to improve mission effectiveness through the application of technology. TechSolutions uses rapid prototyping to meet specific requirements, with each project structured around definable metrics, and appropriate acquisition/test systems by an integrated product team. While neither a substitute for the acquisition process nor a replacement for systems commands, TechSolutions provides prototypes that deliver solutions to address immediate needs that can be easily transitioned by the Fleet/Force acquisition community.

The problem we are trying to solve is that the pace of technology development is often faster than the DoD Planning, Programming, Budgeting and Execution (PPBE) process can respond. Our Technology Insertion for Program Savings (TIPS) program is structured to provide current-year funding (inside the PPBE process), eliminating the time lag inherent in the PPBE cycle. The general scope of the program is funding up to \$2 million for development efforts taking no more than two years to complete, coupled with strong Fleet/Force support and resource sponsor commitment to fund moving the technology into the acquisition Program of Record (POR) or operating system. TIPS focuses on improvements that substantially reduce operating and support costs for warfighting systems.

In partnership with ONR, Naval Warfare Development Command (NWDC), Naval Postgraduate School, Naval War College and Marine Corps Warfighting Lab (MCWL) assess new warfighting concepts and emerging technologies. Initiatives in support of our maritime strategy are applied, tested, analyzed and refined through war games, exercises, experiments and operational lessons learned.

S&T Highlights

The Naval S&T portfolio includes a range of projects and supporting programs entering or about to enter the Fleet/Force. Following are examples of these efforts, noting the impact they will have on Sailors and Marines, today and in the future.

Expeditionary Maneuver Warfare and Combating Terrorism

With your Marines, "expeditionary" is a force no larger or heavier than necessary to accomplish the mission. Missions are temporary operations from forward land or sea bases with temporary support in the face of hostile resistance across the spectrum of combat to non-combat missions, with intent to withdraw when the mission is accomplished. This can best be achieved through creation of a Future Middleweight Force which can launch from and return to the sea, reclaim Navy's role as the premier expeditionary force, and project power in increasingly sophisticated anti-access, area-denial (A2/AD) environments.

Key to establishing this Middleweight Force is the requirement to "Lighten the Load" for every individual Marine, as well as the Marine Air-Ground Task Force (MAGTAF). In S&T, this involves research into technologies that will increase speed, agility and operational range across

difficult terrain - while reducing fuel consumption. It includes reducing vulnerability to Improvised Explosive Devices (IEDs) and mines, and developing advanced materials for lighter body armor, improved helmets and better eye protection. We are investing in significantly enhanced over-the-horizon, beyond line-of-sight, restricted environment communications, as well as netted, adaptable sensor systems that can detect, classify, indentify, locate and track low level entities in urban clutter to improve situational awareness and enhance real time tactical decision making.

We also invest in research about ways to improve training efficiency based on cutting edge, neuro-cognitive, psychologically-driven instructional strategies. Improving the proficiency with resilience of Marines enables them to more effectively, efficiently observe, orient, decide and act (OODA) during complex, stressful combat conditions enhances their ability to precisely locate and defeat enemy targets in urban areas. At the same time, we are exploring new technologies that provide autonomous air logistics delivery from the Seabase to Distributed Operations Units, as well as enhance self-sufficiency in fuel and water use, and improve maintenance capabilities. Research in resiliency will enable Sailors and Marines to survive and prosper in the brutal environment of close combat, as well as to retain their emotional and mental health after they leave the traumatic stress environment.

Marines operate from a forward-deployed posture to provide immediate crisis response capabilities when U.S. citizens, interests or allies are threatened. Our viability as an expeditionary force hinges on our ability to address challenges involving the way we train and equip our force. In S&T, this involves research into technologies that enable extreme agility from the individual to the MAGTF resulting in total maneuver dominance over the battlespace. On-demand and reduced logistics enables a sustained high tempo of operations, allowing the Corps to out-maneuver any enemy. Marines will out-perform and out-think the enemy through our ability to understand the battlespace in greater detail, make operational and tactical decisions with greater understanding of enemy intentions, with respond to enemy decisions more rapidly by getting inside the enemy decision cycle. To help achieve these goals, we are creating a generalized, small unit, leader-centric training framework based on codified learning models and theories and delivering technology and knowledge products for the USMC Training and Education Command (TECOM) that maximize learning and skill acquisition at minimal cost.

Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)

The most critical enabler of rapid, accurate decision-making is having a clear picture of the dynamics of the battlespace. Automated development of this picture becomes critical at the tactical edge where decisions must be made in real time. However, critical pieces of information often reside in proprietary and mission networks and are not easily shared with other missions or integrated with other data. This leads to inefficient use of band-width – and if the same or similar data is required by several different missions on separate networks, multiple transmissions of the same data often result. Since accurate decision making is all about the data, access to critical relevant data regardless of source requires that we pursue a data-focused information architecture/environment, as opposed to the current individual systems architectures.

To achieve this goal, ONR is working with the Deputy CNO for Information Dominance (N2/N6) and Program Executive Officers (PEOs) to develop Naval Tactical Cloud reference implementation that is scalable across platforms and meets the critical timelines of tactical environments. While cloud technologies for environments connected by fiber optics or other high bandwidth connectivity are commercial products, clouds at tactical levels (such as ships and platforms operating in Disrupted, Detached, Intermittent, and Limited bandwidth environments) require significant enhancements such as automation in information discovery; data synchronization across a distributed cloud; dynamic, automated, policy-based, information prioritization; automated identity and authentication management, and synchronization. For this, we can leverage much of the basic cloud architecture from the Intelligence Community and Army, and focus S&T on enhanced technologies and data science to automate much of the underlying sense-making.

The underlying technologies that integrate the operational and tactical pictures require significant advances in ingesting numerous, disparate data types such as Communications Intelligence (COMINT), Signals Intelligence (SIGINT), Electro-Optical/Infrared (EO/IR) images, radar, Human Intelligence (HUMINT), and financial and social transactions into a common structure – and developing the advanced analytics to extract the critical factors that enable rapid, accurate decision making. In addition to building these rich operational and tactical pictures for the warfighter, a rigorous mathematical schema for computing the associated confidence level in resulting pictures due to uncertainty, incompleteness, imprecision, and contradiction in the underlying data is required. Improving confidence levels often requires optimized refocusing of limited sensing, computational, and human resources on specific mission picture elements for acquiring data the system does not have. Resolving these issues requires considerable resources and often cannot be done within a mission's tactical or strategic timelines without significant automation.

This is only one aspect of our effort to focus on Cyber Threats to Naval operations and respond with robust efforts to develop the technology to operate in Cyberspace and across the electromagnetic spectrum as emerging war fighting domains – and enable operations in an A2/AD environment. ONR's goal is to partner with network defenders, acquisition sponsors and Fleet/Force operators to develop advanced capabilities to defend networks and assure operational capability and resilience in Cyberspace.

Ocean Battlespace Sensing

One of the Navy's premier goals is to exploit the environment to our advantage by accurately predicting and adapting to ocean, air, littoral and riverine environments on tactical and strategic time scales. To achieve this goal, we invest in S&T to provide mobile autonomous environment sensing, match predictive capabilities to tactical planning requirements, and develop systems that will adapt to environmental variability. In short, we are working to integrate atmospheric and ocean models to enable better forecasting.

In partnership with the National Oceanic and Atmospheric Administration (NOAA) and academic partners, we developed the Hybrid Coordinate Ocean Model (HYCOM), a numerical model data assimilation system to provide daily to weekly forecasts of global ocean conditions.

We developed the next generation Tropical Cyclone Forecast model, which will provide improved intensity forecasts. Additional research investments include developing a better understanding of how surface winds affect upper ocean dynamics and energy fluxes across the ocean boundary layer, as well as improving knowledge of Arctic environments and the ability to forecast operational conditions with longer lead times. Construction has begun on the newest University-National Oceanographic Laboratory System (UNOLS) Ocean Class Research Vessels. Auxiliary General Oceanographic Research Ship (AGOR 27) *Neil Armstrong* will be delivered in 2014 and assigned to Woods Hole Oceanographic Institution, while AGOR 28 will be delivered in 2015 and assigned to Scripps Institution of Oceanography.

In addition, we are developing rapid, standoff mine countermeasures to support unencumbered maneuver of combatants, assure access, ensure strategic mobility and sustainment, decrease mine countermeasure (MCM) hazards to ships, sailors and Marines, and increase the standoff range of combatants from minefields. ONR experiments with sensing and autonomy technologies help enable small vessels to operate at night, in all weather, at higher speeds, with significantly less difficulty and risk over very large, poorly mapped riverine systems. Our Advanced Undersea Weapon System (AUWS) will deliver and distribute targeting sensors and remotely controllable or autonomous weapons into chokepoints or channels to neutralize maritime threats for extended periods. Coupled with Advanced Sonar Technology for High Clearance Rate MCM in the surf zone and autonomous minehunting payloads for Unmanned Surface Vehicles (USV), ONR is reducing timelines associated with detecting, identifying and clearing floating, drifting, moored and bottom mines in shallow water.

Finally, ONR supports research to improve anti-submarine wide area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. We continue to provide S&T to mitigate the effects of Naval acoustic systems on marine mammals to facilitate Navy acoustic training and operations. We provide S&T to improve probability of kill (Pk) capability of undersea weapons, and enable new undersea weapon concepts of operation. Associated projects include the Remote Aerial Sonar and Communications Laser (RASCL), Affordable Compact Bow Sonar for large deck surface ships, holding threat submarines at risk in forward areas, screening transiting battle groups, and providing torpedo defense for individual ships.

Sea Warfare and Weapons

ONR's major focus in this area is to improve surface, submarine, ground, and air platforms, as well as undersea weapon performance to meet future requirements and maintain technological superiority. S&T provides Naval options for advanced electrical systems and components, and for survivable, agile, mobile, sustainable, manned and unmanned, surface and sub-surface sea platforms, and undersea weapons. ONR also supports research to improve aircraft survivability and rotor/prop performance across a wider flight envelope. In addition, we invest in S&T to develop energy dense, safe and reliable energetic materials, as well as to explore the entire spectrum of power and energy technologies.

An important focus of ONR's Advanced Naval Materials research is Integrated Computational Materials Engineering (ICME) which links basic research in physics and chemistry to reliable, cost-effective materials processing and manufacturing design to meet critical Naval requirements. ICME advances experimental capabilities that move material science from the analog to digital age by emphasizing model-guided experimentation at nano-, meso- and macro scales to discover and articulate materials interactions. It also explores the development of high performance functional and structural materials, including metals, cellular and composite materials, welding and joining, and bulk nano-material processing.

This effort supports the Materials Genome Initiative for Global Competitiveness, coordinated by the White House Office of Science and Technology Policy. Goals include building the Materials Innovation Infrastructure, supporting more collaborative, concurrent materials development and system design, and establishing educational underpinnings necessary to support these changes.

An example of the way we do business worldwide is the Asia-Pacific Technology and Education Program (APTEP). APTEP's goal is to promote commerce and partnerships in the Asia-Pacific region through advances in alternative energy research, technology development and education. This includes development of U.S. research capabilities, a U.S. workforce to develop and implement appropriate technologies, and a U.S. economy providing technologies to meet Asia-Pacific needs. In addition, APTEP promotes partnerships with Asia-Pacific nations to encourage the open exchange of technology advances and educational opportunities.

Another example of how we do business is the Energy Systems Technology Evaluation Program (ESTEP), which demonstrates advanced energy technologies using Navy/Marine Corps facilities as test beds. ESTEP data is used to evaluate performance and reliability of energy technologies under various environmental and operating conditions and provide baseline data required for inclusion in energy efficiency systems and equipment procurement specifications. The focus is on innovative pre-commercial and nascent commercial energy technologies obtained from open market sourcing, including companies from the venture capital and small business communities.

Each ESTEP project requires participation by DoN civilians, and military personnel or veterans in key technical and business roles in order to provide training and educational opportunities for the DoN energy workforce. Participants include students in technical and business studies at the Naval Post Graduate School (NPS). NPS, Navy Facilities Command's Engineering and Expeditionary Warfare Center (EXWC), and Space and Naval Warfare Systems Command (SPAWAR) San Diego, have key roles in education, development of information networks, installation design, construction, and security – and lead implementation of the ESTEP program. In addition, a veteran's outreach effort is being developed for the San Diego region, with special emphasis on building links to veteran's programs already established at San Diego State University, including the Troops to Engineers program.

When implementing technology demonstrations at Naval installations and in the private sector, the greatest hurdles are not necessarily technology challenges, but regulations, restrictions, and permits, not to mention fiscal constraints, policies, and other institutional hindrances that can delay and prevent implementation. Therefore, a thorough knowledge of this complex technical,

financial, institutional, and bureaucratic environment by project managers will facilitate project implementation and enable experienced, well-trained energy managers to improve the process.

After the House of Commons was destroyed by one of the last bombs in the Battle of Britain, Winston Churchill encouraged parliament to rebuild, saying, “We shape our buildings, and afterwards our buildings shape us.” That is a principal reason ONR is exploring ways to include Wounded Warriors in Renewable Energy Architectures for Cultural and Human Environments (REACHE) programs – so future facility designs and architectures provide optimal work and living environments for those with disabilities. Such approaches eliminate older architectural design and building techniques that restrict and inhibit human potential. As energy efficiency and technology are already major components for architectural design and building technologies, energy career choices by Wounded Warriors can bring unique personal knowledge to advance the development and implementation of alternative energy architectures.

Warfighter Performance

Warfighter Performance S&T requires that ONR identify and exploit key principles from nature to design, control and power autonomous systems; provide improved processes, materials and sensors; and to develop synthetic biology tools and applications to support the Naval force. Biocentric technologies offer a variety of enabling capabilities, including bio-inspired autonomous vehicles, acoustic/seismic discrimination systems, microbial fuel cells for sustainable power, engineered plants that produce energetic material precursors, and diagnostic tools to assess the health of marine mammals.

Human Factors and Organization Design Systems improve small team, platform, task force, and battle group operations by enabling technology development to accommodate human capabilities and limitations. ONR S&T initiatives include advancing system technologies that incorporate state-of-the-art social and cognitive sciences into existing and developing systems. The goal is to enhance performance, improve the timeliness and quality of operational decision making, develop strategies to mitigate high workload, resolve ambiguity, reduce manning requirements, and improve situational awareness and speed of command through a deeper understanding of human capabilities and limitations.

Training technologies provide S&T to design virtual networked learning environments to increase a sailor’s and marine’s skill, knowledge, expertise and experience in critical warfighting tasks. ONR objectives are to enhance Navy and Marine Corps ability to effectively and affordably train in classroom settings, simulated environments, and while deployed. System and personnel readiness are enhanced by matching the right people with the right skills to systems designed for safe, effective, and efficient operation.

Medical technologies provide S&T to improve the health, well-being, protection and survival of personnel in undersea, shipboard and expeditionary settings. They provide medical equipment, diagnostic capabilities, and treatments that improve safety and enhance warfighter performance and resilience under adverse conditions. For example, ONR develops solutions for hemorrhagic problems associated with combat casualty care, new approaches to prevent injury and disease in

hazardous environments, and continues to address noise induced hearing loss by reducing noise at the source, limiting exposure, and developing of protective technologies.

Human subject research is critical to support the Navy and Marine Corps warfighter, training and operational capability, and Navy Medicine. Many RDT&E activities designed to respond to Fleet/Force requirements necessitate human subject participation. As part of the DON Human Research Protection Program, ONR is responsible for implementation of human subjects protections in the Navy's systems commands, operational forces, training units, and at Navy-sponsored extramural institutions. ONR reconciles the competing priorities of conducting potentially risky research involving human subjects and compliance with federal, DoD, and DON human protection policies.

Naval Air Warfare and Weapons

ONR's Naval Air Warfare goal is to develop, demonstrate and transition technologies to expand Naval weapon system stand-off ranges and reduce engagement timelines to enable rapid, precise, assured defeat of moving land, sea and air targets. We are developing directed energy technologies for defense against advanced cruise missiles, small boats, and asymmetric threats. We invest in research to develop advanced propulsion for high speed weapons and demonstrate key technologies associated with high acceleration, high temperature and high strength materials. We are pursuing automatic and aided target recognition technologies and collaborative weapons behavior. ONR also supports research for standoff detection of Weapons of Mass Destruction (WMDs) and component nuclear materials on ships at sea.

Naval Research Laboratory (NRL)

ONR supports the DoN corporate lab, the Naval Research Laboratory (NRL). The NRL base program develops S&T to meet needs identified in the Naval S&T Strategic Plan and sustains world class skills and innovation in our in-house laboratory. The core scientific research at NRL serves as the foundation that can be focused on any area of interest to rapidly develop technology from concept to operation when high-priority, short-term needs arise. NRL is the lead Naval lab for space systems, firefighting, tactical electronic warfare, microelectronic devices and artificial intelligence. Among our greatest challenges is recapitalizing NRL infrastructure. I invite you to see this facility and learn more about the research undertaken there by the greatest scientists and engineers in the world.

ONR Global

ONR maintains offices in London, Prague, Singapore, Tokyo and Santiago, with our activities closely coordinated with the other services and the Assistant Secretary of Defense (Research and Engineering). We search the globe for emerging scientific research and advanced technologies that enable ONR to address current Naval needs, as well as requirements for future capabilities. ONR Global establishes contacts with international leaders in relevant research, allowing us to gain new perspectives, identify trends, and forecast threats. It also enables us to recruit the world's best scientists and engineers in partnerships that benefit the U.S. and our allies.

ONR Global programs include Science Advisors who communicate Fleet/Force capability needs to the Naval Research Enterprise (primarily Navy labs, warfare centers, affiliated universities) to facilitate development of solutions that transition to the Fleet/Force. Most participants are senior Naval engineers who coordinate experimentation, develop prototype solutions, define transition options, and collaborate with Fleet/Force to define S&T investments to meet future requirements. Our International Science Program provides scientists from academia, government and industry opportunities to engage leading international scientists and innovators. Our technical staff helps establish direct collaboration between ONR/NRL scientists and their foreign counterparts, and identify centers of excellence for Naval S&T. This strengthens our ability to avoid surprise.

Conclusion

The FY 2014 President's Budget request will enable us to continue moving toward enhanced capabilities, more effective partnership between research and acquisition, and strengthened partnerships the Army, Air Force, DARPA and other DoD research organizations – as well as performers outside the Naval R&D system. We strive to tap into the full spectrum of discovery and accelerate the transition of appropriate technologies to civilian use. Our S&T investments represent careful stewardship of taxpayer dollars that will achieve these goals and significantly enhance the safety and performance of warfighters as they serve in defense of the United States. Thank you for your support.



United States Navy Biography

Rear Admiral Matthew L. Klunder **Chief of Naval Research/Director, Innovation, Technology Requirements, and Test & Evaluation (N84)**

Rear Adm. Klunder, a native of Alexandria, Va., graduated from the United States Naval Academy in 1982 and earned his wings of gold at Meridian, Miss., in September 1984. Subsequent flying tours were based in Naval Air Station (NAS) Miramar, Calif.; NAS Patuxent River, Md.; Naval Air Facility Atsugi, Japan; and NAS Lemoore, Calif., where he was qualified in numerous aircraft including the E-2C Hawkeye and F/A-18 E/F Super Hornet.

Klunder has served at sea in Airborne Early Warning Squadron (VAW) 112; VAW-115 as a department head, and as commanding officer; and Carrier Air Wing Two as air wing commander. He has made eight deployments and multiple surge operations to the Atlantic, Pacific and Indian oceans and to the Mediterranean Sea and Arabian Gulf.



Klunder's shore tours include serving as a flight instructor, Naval Air Training and Operating Procedures Standardization officer and Commander Naval Air Force, U.S. Pacific Fleet evaluator at VAW-110; test pilot/project officer at Force Warfare Test Directorate; senior operations officer and Single Integrated Operational Plan officer at the Joint Staff J-3/National Military Command Center; Joint Staff liaison officer and section chief at the U.S. State Department; Combined Air Operations Center deputy director at Al Udeid Air Base in Qatar; deputy director for Information, Plans, and Security for OPNAV N3/N5; 83rd commandant of Midshipmen at the U.S. Naval Academy; and director of Intelligence, Surveillance and Reconnaissance Capabilities Division, OPNAV N2/N6F2. Highlights during these tours include receiving the 1988 Hawkeye of the Year award, the 1991 Test Pilot of the Year award, and the 2002 George C. Marshall Statesman award.

In November 2011, he became the 24th Chief of Naval Research, with additional duties as director, Test Evaluation and Technology Requirements.

Klunder received his bachelor's degree from the U.S. Naval Academy, a master's degree in Aerodynamics and Aviation Systems from the University of Tennessee, and a master's degree in Strategic Studies from the National War College.

He has flown more than 45 different aircraft and accumulated 21 world-flying records. His awards include the Legion of Merit (four Awards), Defense Meritorious Service Medal (two Awards), Meritorious Service Medal (two Awards), Joint Commendation Medal (two Awards), Navy and Marine Corps Commendation Medal (four Awards) and various unit and campaign awards.

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HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND CAPABILITIES
U.S. HOUSE OF REPRESENTATIVES

DEPARTMENT OF THE AIR FORCE
PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON INTELLIGENCE, EMERGING THREATS AND CAPABILITIES
U.S. HOUSE OF REPRESENTATIVES

16 April, 2013

SUBJECT: Fiscal Year 2014 Air Force Science and Technology

STATEMENT OF: Dr. David E. Walker, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

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INTRODUCTION

Chairman Thornberry, Members of the Subcommittee and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2014 Air Force Science and Technology (S&T) Program. This is my first chance to address you as the Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, a position I assumed in August of 2012.

As the nature and sources of conflict throughout the globe have become more diverse and less predictable, our Nation continues to face a complex set of current and future security challenges many of which are outlined in *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense*, the defense strategic guidance issued by the President in January 2012. This guidance directed a renewed focus on the Asia-Pacific region, as well as continued emphasis on the current conflicts in the Middle East. The Air Force's enduring contributions to national security as part of the Joint team are more important now than ever before and we must remain agile, flexible, ready and technologically-advanced. Over the last year, the Air Force has aligned our S&T efforts to best support the Defense Strategic Guidance within current fiscal constraints. Our S&T Program supports the Air Force capabilities fundamental to the major priorities of the guidance, such as deterring and defeating aggression, projecting power in anti-access and area denial environments, operating in the space and cyberspace domains, and maintaining a safe, secure and effective strategic deterrent. The Air Force S&T Program plays a vital role in our Nation's security by creating compelling air, space and cyberspace capabilities for precise and reliable global vigilance, reach and power.

The Chief of Staff of the Air Force, General Mark Welsh III, recently stated in his vision for Airmen that our Service is "fueled by innovation." Our single, fully integrated S&T Program is truly at the forefront of this innovative spirit and stems from several enduring tenets. First, we must prepare for an uncertain future and investigate game-changing technologies to affordably transition

the art-of-the-possible into military capabilities. To support the Air Force Core Functions, we must create technology options across a wide spectrum ranging from institutionalizing irregular warfare capabilities to providing new capabilities to operate effectively in cyberspace and across all domains. We must demonstrate advanced technologies that address affordability by promoting efficiencies, enhancing the effectiveness, readiness, and availability of today's systems, and addressing life cycle costs of future systems. In keeping with our Service heritage, we must continue to foster an appreciation for the value of technology as a force-multiplier throughout the Air Force. We must maintain the requisite expertise to support the acquisition and operational communities and modernize and improve the sustainability of unique research facilities and infrastructure. Finally, we will leverage and remain vigilant over global S&T developments and emerging capabilities to avoid technological surprise and exploit art-of-the-possible technologies for our military advantage.

AIR FORCE S&T FISCAL YEAR 2014 PROGRAM

The Air Force Fiscal Year 2014 S&T Program investments support a robust and balanced foundation of basic research, applied research, and advanced technology development that will provide demonstrated transition options to support future warfighting capabilities.

As a brief overview, adjustments were made within the S&T portfolio to focus investments in the most promising technologies to develop future warfighting capability. We are continuing emphasis in our propulsion portfolio by investing in the development of adaptive turbine engine technologies which will provide optimized fuel efficiency and increased performance capabilities over a wide range of flight regimes. We have emphasized research in hypersonics technologies and in electronic warfare areas to provide the capability to counter adversary anti-access and area denial approaches and effectively engage time sensitive targets. Based on the current and forecasted cyberspace capabilities, threats, vulnerabilities and consequences outlined in our recently published

Cyber Vision 2025 document, we aligned and emphasized our cyber S&T investment in four areas: mission assurance, agility and resilience, optimized human-machine systems, and foundations of trust. We have also emphasized the development of technologies to address limiting capability factors of human performance in military missions including autonomy, data to decisions and human systems research. I will highlight some of these adjustments later in my testimony.

AIR FORCE S&T PROGRAM PRIORITIES

The Air Force Fiscal Year 2014 S&T Program supports the following overarching priorities that are detailed in our Air Force S&T Strategy document.

Priority 1: Support the Current Fight While Advancing Breakthrough S&T for Tomorrow's Dominant Warfighting Capabilities

While developing technologies to equip our forces of tomorrow is the primary objective of any S&T portfolio, our dedicated scientists and engineers have been equally motivated over the last decade to ensuring needed technologies get into the hands of our warfighters today. This valuable near-term S&T investment has saved lives in the current fights and continues to pay dividends as we transition to other focus areas in the long term. I would like to share with you a few examples of how we have supported our warfighters over the last year and how those technologies are being poised to sustain and increase military capabilities of the future.

As an example of one method, the Air Force has executed a rapid reaction process through the Air Force Research Laboratory since 2005 which has provided rapid S&T solutions to the urgent needs of Air Force Major Commands (MAJCOMs), Combatant Commands (COCOMs) and other Defense agencies. Through focused interaction with warfighters and often partnership with other Agencies, the process leverages the breadth and depth of knowledge within the laboratory and its external "innovation network" of academia and industry to deliver accelerated technology solutions in approximately one year or less.

This rapid reaction process has been used to develop warfighting capabilities to meet United States Central Command (CENTCOM) Joint Urgent Operational Needs including efforts such as Blue Devil Block 1. Blue Devil Block 1 is a persistent intelligence, surveillance, and reconnaissance (ISR) capability demonstrating the first-ever integration of wide area field-of-view and narrow field-of-view high definition day and night sensors cued by advanced signals intelligence sensors. Imagery and data are transmitted in near-real-time to an individual soldier on the ground or a Blue Devil ground station where multiple sensor data is rapidly fused for real time cueing and decisions. This new technology and lessons learned from testing in theater will improve capabilities in future systems, especially those poised for engagements where reaction timelines and aircraft access will be more challenging. In addition, the Air Force is rapidly working a variety of S&T solutions to address MAJCOM operational needs for rapid landing site survey and preparation, improved collaboration using existing infrastructure and information, and increased global command, control and communication (C3) connectivity. The Air Force has a strong record of nurturing these types of game-changing concepts using modest S&T funds along with partnerships with customers to transition technologies quickly to warfighters while leveraging the investment to inform and enhance the development of future technologies.

Even outside of the defined rapid reaction process, the Air Force S&T Program has been instrumental in quickly bringing new or enhanced operational capabilities to warfighters worldwide. For example, we are improving awareness of the global space operations through Air Force S&T support to the Joint Space Operations Center (JSPOC) at Vandenberg AFB, California. In 2011, the Air Force Research Laboratory deployed a modern data fusion and display prototype which provides a Windows-type user interface for the 20,000 object space catalogue, modernizing from the text-based system used for the last 50 years. The prototype system provides near real-time monitoring of all orbiting U.S., commercial and foreign spacecraft assets within a common

operating picture reducing operator workload while alerting them to events in a more timely fashion. It was used in October 2012 to monitor the breakup of a Russian Breeze-M rocket body and ensure that orbiting operational space assets were safe from the newly created space debris. As this technology is transitioning to the operational Air Force through the JSPOC Mission System (JMS) program at the Space and Missile Systems Center (SMC), the Air Force Research Laboratory now provides continued upgrades for space operations on tight, six-month spirals and accelerates transition of critical S&T products to Air Force capability.

The models of development for these technologies, as well as lessons learned, are now informing our research efforts to effectively manage and utilize the volumes of data created by the vast array of fielded sensors. While we have developed tools to fuse data from multiple sensors and sources to assist intelligence analysts in exploiting the data, most of these tools have not yet been integrated into our standard tactical intelligence processing system, the Defense Common Ground Station (DCGS). To facilitate this transition, we are building a Planning and Direction, Collection, Processing and Exploitation, Analysis and Production, and Dissemination (PCPAD) - Experimental Cell, or PCPAD-X. This will be an operationally-representative environment and innovative approach for research, development, experimentation, demonstration, and objective evaluation to facilitate transition of technologies for mission driven PCPAD. It will provide a realistic “analyst-in-the-loop” environment which does not exist today, complete with validated subjective and objective performance metrics, for testing potential analysis capability improvements. This environment will allow us to run existing and new analytical tools through the PCPAD-X to more quickly and affordably identify “best of breed” tools for transition.

The Air Force S&T Program is also supporting the current F-22 Raptor fleet while planning to enhance warfighter effectiveness in next generation platforms. The Air Force Research Laboratory supported the Safety Investigation Board, Scientific Advisory Board, the Root Cause

Corrective Action analysis, and is a major participant in the Air Combat Command-led F-22 Life Support Systems Task Force. To address life support issues, laboratory personnel provided expertise on oxygen systems, toxicology, aerospace medicine/physiology, epidemiology, and bio-environmental engineering. Scientists and engineers from the laboratory identified on-board oxygen generating system (OBOGS) limitations and recommended parameters for OBOGS challenge testing, resulting in a new DoD Air Quality Standard. They also developed and flew a helmet-mounted pulse oximeter for use on the F-22 in 90 days and then transitioned the design for fleet-wide operational fielding. To address multiple Air Force demand signals and future concerns due to the increasingly complex and capable fighter aircraft in development, the Air Force has begun reconstituting aerospace physiology/toxicology core competencies at the Air Force Research Laboratory. Using research and technology developed in response to the F-22 issues, this program will provide evidence-based understanding of pilot physiologic response to new air platforms, characterize physiologic performance for new flight envelopes, understand physiologic impacts due to toxic exposure, and understand unexplained cognitive dysfunction that can occur in some pilots.

Priority 2: Execute a Balanced, Integrated S&T Program that is Responsive to Air Force Service Core Functions

Our Nation depends on the Air Force to counter a broad range of threats that could limit our ability to project global reach, global power, and global vigilance. Even as we emphasize focus on the Asia-Pacific region, we are aware that we cannot predict with certainty the time, place, or nature of the next contingency where airpower will be needed. The Air Force's technological advantage is threatened by the worldwide proliferation of nuclear weapons and advanced technologies, including integrated air defenses, long-range ballistic missiles, and advanced air combat capabilities. In addition, advances in adversarial capabilities in space control and cyber warfare may limit Air Force operations in air, space, and cyberspace. Some of these technologies are attained with relatively

minimal cost; greatly reducing the barriers to entry that have historically limited the reach and power of non-state actors, organized militias, and radical extremists. Today's strategic environment indicates the military need for flexibility and versatility which requires a shift to inherently agile, deployable, and networked technologies and systems—including legacy systems—designed to accomplish a multitude of missions.

Through prioritization and planning, the Air Force Fiscal Year 2014 S&T Program provides the technical edge to affordably meet these threats during this time of fiscal constraint. Since high-payoff technologies are needed to sustain our air, space, and cyberspace superiority in an increasingly competitive environment, we are smartly investing in a broad portfolio of technologies aligned with the Defense Strategic Guidance that are balanced across the warfighter's need for near-term, rapid-reaction solutions; mid-term technology development; and revolutionary, far-term capabilities.

At the Service level, the Air Force has matured its S&T planning processes a great deal over the last year by improving the alignment between S&T efforts and capability gaps outlined in Air Force Core Function Master Plans (CFMPs). Our robust research program pushes the technological state of the art across a range of areas for potential military application as well as being responsive to technology needs expressed by the operational community. The established S&T planning governance process ensures S&T investments are well understood, structured for success, and poised for transition when completed. This process is the backbone of Air Force S&T contributions to the larger DoD priorities and strategies and has provided us opportunities to lead the Department's research and strategic planning efforts in some areas including cyber, autonomy, electronic warfare and manufacturing technology. These planning efforts also support the Department's *Better Buying Power 2.0* initiatives to achieve greater efficiencies in acquisition.

including developing stronger partnerships with the requirements community, using the technology development phase for true risk reduction and incentivizing productivity and innovation in industry.

To illustrate how the Air Force S&T Program is supporting our national security by providing the necessary speed, range, flexibility, precision, persistence, and lethality across all domains (air, space and cyber), I would like to highlight some of our efforts in the areas we are leading for the Department as well as across our portfolio of contributions:

Speed can contribute to survivability of Air Force systems and allow us to engage time sensitive targets even in the anti-access/area-denial environments we increasingly expect to encounter in the future. Starting in early Fiscal Year 2011, the Air Force S&T community—in collaboration with industry—developed roadmaps for high speed technology options for Air Force missions in anti-access/area-denial environments. The Air Force focused its S&T investments in two key areas: technology for survivable, time-critical strike in the near term and a far-term penetrating regional Intelligence, Surveillance, and Reconnaissance (ISR) aircraft.

Our survivable, time critical strike technology effort includes research and advanced technology development efforts that support the maturation to Technology Readiness Level 6 (TRL 6) of Mach 5.0 plus cruise missile technology. Detailed roadmaps have been developed, which include advanced guidance technology, selectable effects ordnance, airframe technology, and expendable cruise propulsion. The technologies requiring early flight testing are included in a demonstration effort that will begin later in Fiscal Year 2013 called the High Speed Strike Weapon (HSSW).

HSSW is an integrated technology demonstration that was proposed by the same Air Force and industry team who developed the overall Air Force S&T plan/roadmaps in the high speed area. Key to HSSW's tactical relevance is its compatibility with Air Force 5th generation platforms to include geometric and weight limits for internal B-2 Spirit bomber carriage and external F-35

Lightening II fighter carriage. It will also include a tactically compliant engine start capability and launch from a relevant altitude. The flight demonstration will be the first tactically-relevant demonstration of Mach 5.0 plus airbreathing missile technology. This effort addresses many of those items necessary to realize a missile in this speed regime including: modeling and simulation; ramjet/scramjet propulsion; high temperature materials; guidance, navigation, and control; seekers and their required apertures; warhead and subsystems; thermal protection and management; manufacturing technology; and compact energetic booster technologies. The Air Force is actively pursuing a partnership with the Defense Advanced Research Projects Agency (DARPA) on this demonstration to leverage their recent experience in hypersonic technologies that are relevant to HSSW and other hypersonic systems.

Analysis of challenges in the future security environment has made clear that our advanced munitions technology like the HSSW and other existing or advanced munitions will need to operate when the Global Positioning System (GPS) signal is either degraded or perhaps even denied entirely. As such, we have focused on pursuing a number of munitions guidance technologies that will allow us to continue to operate much as we have become accustomed today. These include technologies that expand upon our current anti-jam GPS navigation capabilities and novel technical approaches to navigation such as optic field flow techniques and multi-sensor fusion. These techniques allow the Air Force to harvest information regarding these systems as they traverse through their flight environment and infer the necessary navigation information.

The importance of dominance in the cyberspace domain cannot be overstated as it is a foundation for global vigilance, reach and power. Cyberspace is a domain in which, from which and through which all military missions are performed and is becoming increasingly contested or denied. The Air Force has placed great emphasis on S&T efforts to overcome threats and provide

systems and methods that are affordable and resilient. The Chief Scientist of the Information Directorate of the Air Force Research Laboratory located in Rome, New York (“Rome Lab”), has been charged to chair the collaborative, Joint cyber S&T road-mapping efforts for DoD based on the Laboratory’s history of exceptional cutting-edge cyber research.

Recognizing that sound strategies are the foundation for wise investments, the Air Force Office of the Chief Scientist partnered with operators and technologists from across the Air Force, government, industry, academia, National Laboratories, and Federally Funded Research and Development Centers to develop *Cyber Vision 2025* last year. *Cyber Vision 2025* describes the Air Force vision and blueprint for cyber S&T spanning cyberspace, air, space, command and control, intelligence, and mission support. It provides a long-range vision for cyberspace to identify and analyze current and forecasted capabilities, threats, vulnerabilities and consequences across core Air Force missions in order to identify key S&T gaps and opportunities. The Air Force’s cyber S&T investments are aligned to the four themes identified in *Cyber Vision 2025*: Mission Assurance, Agility and Resilience, Optimized Human-Machine Systems, and Foundations of Trust. *Cyber Vision 2025* and our associated cyber S&T strategy guides the research conducted at the Air Force Research Laboratory ensuring the relevance and efficiency of our technology development for Air Force and national security users.

Air Force S&T efforts in Mission Assurance seek to ensure survivability and freedom of action in contested and denied environments through enhanced cyber situational awareness for air, space, and cyber commanders. Research efforts in automating network and mission mapping are working to provide warfighters with the ability to detect and operate through cyber attacks with threat warning, integrated intelligence, and real-time forensics/attribution. We are also focused on developing technologies to achieve cross-domain integrated effects and determine cross-domain measures of effectiveness (MOEs), including cyber battle damage assessment.

Our research in Agility and Survivability is focused on minimizing future system risk by reducing attack surfaces, segregating critical mission systems, and developing methods to contain attacks. Air Force S&T efforts are creating dynamic, randomizable, reconfigurable architectures capable of autonomously detecting compromises, repairing and recovering from damage, and evading threats in real-time. The Air Force is also enhancing cyber resiliency through an effective mix of redundancy, diversity, and fractionation (i.e., distributed functionality).

We are also working to maximize the human and machine potential through the measurement of physiological, perceptual, and cognitive states to enable personnel selection, customized training, and user-, mission-, and environment-tailored augmented cognition. Air Force S&T efforts are developing high performance visualization and analytic tools to enhance situational awareness, accelerate threat discovery, and empower task performance.

The Air Force is developing secure foundations of computing including trusted fabrication technologies, anti-tamper technologies, and supply chain assurance, as well as effective mixes of government, commercial off the shelf, and open source software to provide operator trust in systems (e.g., sensors, communications, navigation, command and control). Research into formal verification and validation of complex, large scale, interdependent systems as well as vulnerability analysis, automated reverse engineering, and real-time forensics tools will improve security at all levels of technology implementation. Further, efforts exploring high speed encryption, quantum communication and, eventually, quantum encryption will further increase the confidentiality and integrity of supporting infrastructure.

The security atmosphere of today, and that which we can visualize in the future, requires our military aircraft to operate in highly contested environments. Manipulation of the electromagnetic spectrum—called electronic warfare—can help us negate the integrated air defenses of our adversaries. Over the years, we have developed stand-off, on-board, and off-board capabilities to

protect fighter and bomber aircraft; however, our adversaries continue to evolve their capabilities at the same time. As the lead for the DoD Electronic Warfare Priority Steering Committee, the Air Force has been charged to facilitate road-mapping efforts for research in new technologies and techniques to be effective against the new threats involving ways to defeat new sensors operating in new frequencies, more elaborate detection methods, and greater computational and networking capabilities of adversaries. The new technologies and techniques being created feed into Air Force and Navy upgrades to a range of military aircraft including fighters, bombers, support and decoy aircraft. For example, the Eagle Passive/Active Warning Survivability System (EPAWSS) effort for the F-15 Eagle is leveraging the Air Force Research Laboratory Sensors Directorate work in advanced digital receiver technology as one key architecture option.

Research in our Directed Energy portfolio has also shown promise in the development of capabilities to defeat our adversary's electronic systems on the ground. In October 2012, the Air Force successfully flight tested a system called the Counter Electronics High Powered Microwave Advanced Missile Project, or CHAMP. During the flight test, the CHAMP cruise missile navigated a pre-programmed flight plan and emitted bursts of high-powered microwaves at targets containing a wide range of representative electronic equipment, effectively delivering a functional disable of the systems without harmful effect on people or structures in and around the target area. This successful test culminated the CHAMP Joint Capabilities Technology Demonstration (JCTD) and moved the Air Force closer to providing combatant commanders with a non-kinetic counter electronics capability as a complement to lethal measures, increasing mission options for the warfighter.

The Defense Strategic Guidance pivot to emphasis on the Asia-Pacific region means missions with expanded duration, intermittent communication disruptions, high rate of changing situations, and a larger array of asset capability. These realities require research in both human

systems and performance to better enable warfighters to enhance military capabilities as well as autonomous systems which can extend human reach by providing potentially unlimited persistent capabilities without degradation due to fatigue or lack of attention. Since they are investment priorities, the Department has established cross-Service steering groups for both human systems and autonomy to roadmap and coordinate research efforts in these areas. The Air Force is leading the autonomy steering group and is an active member of the human systems group.

The Air Force envisions that the greater use of autonomous systems will enable United States forces to operate well within the “decision loops” of our adversaries. Such increases in machine autonomy will require humans and automated systems to work as a team, with some level of decision-making delegated to the machine counterpart. We seek to enable the *right balance* of human and machine capability to meet Air Force challenges in the future and are focused on growing autonomous system capability, integrated with the human capacity to perform in a high-tempo, complex decision environment, and to optimize humans working together with machines, both effectively and efficiently.

To achieve this, the Air Force is developing technologies to enable Airmen and machines to work together, with each understanding mission context, sharing understanding and situation awareness, and adapting to the needs/capabilities of the other. The keys to maximizing this human-machine interaction are: instilling confidence and trust among the team members; understanding of each member’s tasks, intentions, capabilities and progress; and ensuring effective and timely communication. This must all be provided within a flexible architecture for autonomy, facilitating different levels of authority, control and collaboration. Current research is focused on understanding human cognition and applying these concepts to machine learning. For example, we are developing efficient interfaces for an operator to supervise multiple MQ-9 Reaper platforms and tools for ISR analysts to better identify and track targets of interest. We are also conducting human

systems research in the areas of decision-making, training, bioeffects, and human-centered ISR. We have increased our emphasis in training research with the objective of providing live, virtual, and constructive (LVC) rehearsal capabilities to increase affordability by reducing training time by 30 percent, increasing training effectiveness by 15 percent, and creating common methods for cross-mission application. As a result of this research, the Air Force will be more efficient and effective while tailoring training and rehearsal to the point-of-need to keep pace with rapidly evolving and complex threats.

Today there is little cross-platform interaction or coordination without a human engaging in the interaction. Therefore, the Air Force is developing cooperation technologies that will allow machines to autonomously synchronize activity and information to take our military capabilities beyond human limitations. Systems that coordinate location, status, mission intent, intelligence and surveillance data can provide redundancy, increased coverage, decreased costs and/or increased capability. The Air Force's research efforts are focused on developing control software to enable multiple, small unmanned air systems to coordinate mission tasking with other air systems or with ground sensors and also on developing munition sensors and guidance systems that will increase operator trust, validation, and flexibility while capitalizing on the growing ability of munitions to autonomously search a region of interest, provide additional situational awareness, plan optimum flight paths, de-conflict trajectories, optimize weapon-to-target orientation, and cooperate to achieve optimum effects.

The Air Force's mission to *fly, fight* and *win* in air, space and cyberspace, requires a tremendous amount of energy. In fact, our Service uses approximately 2.5 billion gallons of aviation fuel per year and is the largest fuel consumer in the federal government. As such, we are pursuing research into technologies to reduce energy demand for both legacy and future aircraft.

For example, in conjunction with Air Mobility Command, the Air Force Research Laboratory is conducting promising research to reduce drag on C-130 Hercules aircraft, one of the primary fuel consumers in our legacy fleet. This low-cost aft-body flow control research, consisting of microvanes and finlets, will reduce the flow separation around the cargo ramp and the horizontal junction with the fuselage. Flight testing to date has shown that these devices can save three to five percent of total aircraft drag during normal flight conditions. The Air Force has developed and funded a two-phase flight test process to optimize the design of the devices to provide the maximum fuel savings possible without having detrimental effects on airdrop operations, basic loadability, handling qualities and structural dynamics. Phase I (early operational assessment) testing was successfully completed at Yuma Proving Ground in November 2012. Phase II (fuel flow, handling qualities and structural dynamics) testing is on schedule for late spring of this year. This modest research investment could save approximately \$130,000 per year, per aircraft and the resulting production versions are installable at the field level, meaning minimal downtime for the warfighter and depot level maintenance savings.

For the longer term reduction in energy demand, the Air Force is investing in the development of adaptive turbine engine technologies which have the potential to reduce fuel consumption by 25 percent in comparison to current turbine engines by enabling optimized performance over a wide range of flight conditions. These technologies also increase capability in anti-access/area denial environments by increasing range by 25 to 30 percent or increasing time-on-station by 33 to 40 percent.

The Air Force initiated investment in adaptive engine technology through the Adaptive Versatile Engine Technology (ADVENT) program. This research is being leveraged by our current Adaptive Engine Technology Development (AETD) program. AETD will mature ADVENT and additional technologies, including inlet and exhaust systems, to TRL 6 to reduce risk for follow-on

activities and facilitate integration into multiple platforms to realize operational benefits. Investments in these efforts helps us reduce energy demand, bridge the “valley of death” between S&T and potential acquisition programs, and help maintain the U.S. industrial technological edge and lead in turbine engines.

The Air Force is also the lead for the Department in the development and demonstration of technology solutions that decrease manufacturing risk and increase weapon system affordability for aerospace propulsion, structures and ISR systems. Simply stated, a more capable and lean warfighting force requires a much more efficient and responsive manufacturing and industrial base than we currently have today. The Air Force Manufacturing Technology program explores strategic issues and opportunities in manufacturing and industrial readiness including moving manufacturing considerations to bear earlier in the design cycle to reduce acquisition cost and risk; enabling a seamless life-cycle value stream management through a cradle-to-cradle digital design thread to improve process control, optimization, and agility; integrating the industrial base enterprise to predict, identify, and react to supply chain issues; and creating the factory of the future with flexible, robust tooling and machine cells for limited part runs.

For example, the Air Force Manufacturing Technologies program conducts Manufacturing Readiness Assessments on new technology, components, processes, and subsystems in order to define the current level of manufacturing maturity and identify associated risk. A number of major DoD weapon system suppliers and Original Equipment Manufacturers (OEMs) have integrated manufacturing readiness levels into their gated technology transition processes to help decide when a technology is mature enough to use in a product design. As a result, prime contractors and other OEMs are making better decisions about which technologies to include in product designs resulting in reduced cost, schedule and performance risk. This past year, the advanced manufacturing propulsion initiative continued activities to reduce the weight and cost of turbine engines through

advanced manufacturing of light weight castings and ceramic composites. The advanced next generation radar and coatings affordability projects continue to reduce technology cost and manufacturing risk to systems such as the F-22 and F-35 aircraft.

The Air Force S&T Program is also supporting the President's Materials Genome Initiative (MGI) aimed at doubling the speed and reducing the cost of discovering, developing and deploying new advanced materials. The MGI is engaging all stakeholders in the materials development community which spans academic institutions, small businesses, large industrial enterprises, professional societies, and government. Our supporting effort is called Integrated Computational Materials Science and Engineering (ICMSE) and its objective is to develop quantitative and predictive techniques for the field of materials science and engineering (MSE) to bring similar benefits to MSE that have been realized from Finite Element Analysis or Computational Fluid Dynamics in aircraft design.

ICMSE requires new, science-based capabilities in order to create fresh approaches for the design of materials. Coupled with materials design is the need to develop a robust, two-way conduit between materials design, manufacturing, and component design. The Air Force, Johns Hopkins University, and the University of Illinois have teamed to form a center-of-excellence (COE) to innovate new solutions for pervasive ICMSE issues, including physics-based multi-scale modeling and uncertainty quantification. While the COE explores basic science underpinnings for ICMSE, nearer-term approaches to integrate the continuum spanning materials design and vehicle design are being explored in concert with vehicle/component designers, manufacturers, materials suppliers, and materials developers. Two Air Force-relevant engineering problems (high-temperature metals and composites) establish the scope on which to develop, test and demonstrate approaches for ICMSE.

Research in our space portfolio also addresses how to accomplish the Air Force mission with resiliency and affordability. For example, we are seeking to provide added protection to our satellites by increasing the robustness and resiliency of the most susceptible spacecraft components which will provide affordable options for a more-defendable space capability. The Air Force collaborates with NASA on research in space communications to extend the frequency trade space and create options for future space communication satellites. We are also continuing to mature technology for next-generation GPS user equipment with anti-jam capability for contested theater operations, including the transitioning of the cold atom technology from basic to applied research which offers great promise for operating in GPS-denied environments. In the space situational awareness area, the Air Force S&T enterprise operates two 3.5 meter class telescopes and several smaller ones that, as well as performing research, are used to support satellite owners in determining the health/status of their satellites using high resolution optical images instead of the traditional radar.

To reduce the cost of space access, the Air Force is researching ways to improve Evolved Expendable Launch Vehicle capability through increased use of multiple payloads. Air Force S&T maintains a long-term investment in pervasive spacecraft technologies, such as more efficient space solar cells that can reduce solar array mass by 40 percent.

Space experiments, such as the current Advanced Responsive Tactically Effective Military Imaging Spectrometer payload on TacSat-3 and the Communications/Navigation Outage Forecasting System, are a critical tool used to develop and prove new technologies and phenomenologies. Future experimental satellites include the Automated Navigation and Guidance Experiment for Local Space, which will research local space surveillance, and the Demonstration and Science Experiment, which will research approaches to counter a space nuclear detonation.

Development of revolutionary, far-term capabilities begins with scientific discovery and the building of foundational knowledge with our investment in basic research. Based on visions of the future established by Air Force leadership, Air Force scientists and engineers identify, nurture and harvest the best basic research to transform leading-edge scientific discoveries into new technologies with substantial military potential. These technologies transform the art-of-the-possible into near-state-of-the-art and offer new and better ways for the acquisition community to address far-term warfighter needs. While it can be more of a challenge to quantify long-term basic research, with the scientists and engineers at the Air Force Office of Scientific Research within the Air Force Research Laboratory actively engaged in worldwide technical communities, the Air Force has leveraged significant investments made by other defense and federal agencies, as well as non-defense and international laboratories, in its on-going efforts to advance basic science.

For example, an Air Force basic research funded project in quantum storage at the University of Maryland has demonstrated for first time that multiple images can be stored and retrieved at different times based on interaction between light and matter. In this atomic memory, light signals can now be stored as patterns in a room-temperature vapor of atoms that are tailored to absorb and later re-emit messages on demand. Quantum storage capabilities will exploit quantum effects for computing and communications are vital to increasing the speed, capacity and security of our networks and computer systems of the future. The researchers are continuing to understand entangled quantum memories for use in securing long distance transmission of secure information through optical fiber systems.

While most of our investments in the Air Force S&T Program focus on developing and advancing technologies for the future, S&T also has an important role to play in providing technology options to increase the availability and decrease the life cycle costs of our legacy platforms now. Many of the Air Force's current aircraft were manufactured decades ago and are

experiencing age-related issues, such as cracking and corrosion, especially after nearly 20 years of unabated use. Our S&T efforts to address sustainment issues not only pay dividends now but also provide options when designing and building future systems. We are focusing our sustainment efforts in three areas: inserting new technologies in legacy systems to better and more affordably sustain the fleet, developing technology-based approaches to improving fleet health management and introducing new design approaches for future systems and components.

For example, over the last year our research had yielded results in addressing critical cracking issues with the C-5 Galaxy aircraft floor bulkhead end fittings. The cracks, caused by stress corrosion, led to increased maintenance costs and reduced the amount of cargo that could be carried on the aircraft. Using a new, more stress corrosion-resistant aluminum alloy, researchers developed a new die forging process by which all of the 92 fitting shapes required for the C-5 bulkhead could be produced using only two separate forging dies. The new technology, which has now been transitioned to the Warner Robins Air Logistics Center, provides many benefits including a 25 percent overall cost savings, an 80 percent reduction in fabrication time and a 60 percent increase in service life of the fittings.

The Air Force is also a key member of the multi-Service Advanced Technology Demonstration (ATD) addressing propulsion sustainment for current and future aircraft. The team is working to provide hot section component durability which is a significant driver of maintenance costs. This effort is focused on advanced turbine cooling and aerodynamics technologies that reduce weight and allow engines to run hotter at the same material temperature thereby producing more thrust. These types of technologies are aimed at benefitting turbine engine programs across DoD including current programs, such as the F-35, as well as future Air Force programs, such as the Long Range Strike bomber.

Priority 3: Retain and Shape the Critical Competencies Needed to Address the Full Range of S&T Product and Support Capabilities

The U.S. Air Force is the most technologically advanced air force in the world – and we intend to keep it that way. Technology is part of every mission we perform, and innovative and technically-savvy Airmen are our most important asset. The Air Force ensures we continue to have war-winning technology by careful and proactive management of our Science, Technology, Engineering, and Mathematics (STEM) workforce.

Through implementation of *Bright Horizons*, the Air Force STEM Workforce Strategic Roadmap, and the Air Force Systems Engineering Strategic Plan, we continue to develop and retain a workforce with the skill sets necessary to create compelling air, space and cyberspace capabilities for precise and reliable global vigilance, reach and power. The Air Force is progressively developing a highly qualified engineering workforce with the engineering competencies required to support the acquisition of warfighting systems. We continue to be appreciative of the Laboratory Demonstration authority and are investigating opportunities to expand the program to our entire STEM workforce.

The Air Force conducted an in-depth review of our STEM requirements and is revamping our accession and recruiting processes to help career field managers obtain the right skill sets. Over last eight years in the Science, Mathematics, and Research for Transformation (SMART) Scholarship Program, the Air Force averaged 60 scholarships per year to scientists and engineers; after payback commitment, we retained 88 percent of scholars in Air Force jobs. Through an innovative Section 219 (of the Duncan Hunter National Defense Authorization Act of 2009) workforce initiative, the Information Assurance Internship funds 10 to 20 college juniors and seniors in STEM disciplines to study the science of information assurance and information warfare on Air Force problems. For instance, last year's interns, who averaged a 3.8 grade point average,

developed a mathematical model for the MQ-9 Reaper remotely piloted vehicle in a contested cyber environment. The Air Force utilizes this initiative to attract and offer employment to the best and brightest cyber students. An objective of our workforce strategy is to improve the pool of diverse candidates available to enter our STEM workforce. We also continue to have a vibrant relationship with Historically Black Colleges and Universities and Minority Serving Institutions (HBCU/MI), who conduct research projects, improve infrastructure, and intern with the Air Force Research Laboratory in support of the Air Force mission. The Air Force uses essential tools, such as the SMART Program and the Information Assurance Internship, to renew and grow the required skill sets critical for Air Force mission success. The Air Force remains dedicated to improving our force management processes to attract, recruit and retain STEM talent.

Priority 4: Ensure the Air Force S&T Program Addresses the Highest Priority Capability Needs of the Air Force

As discussed earlier, the Air Force S&T planning and governance process ensures the Air Force S&T program addresses the highest priority capability needs of our Service. The Air Force Core Function Master Plans (CFMPs) play a critical role in this process by identifying S&T needs as they relate to capability gaps, requirements, and potential materiel solutions.

Among other things, this process has allowed us to create and execute Air Force Flagship Capability Concepts (FCCs). Key factors in commissioning this type of an Air Force-level technology demonstration effort include having a well-defined scope and specific objectives desired by a MAJCOM. The technologies are matured by the Air Force Research Laboratory with the intent to transition to the acquisition community for eventual deployment to an end user. These FCCs are sponsored by the using command and are vetted through the S&T Governance Structure and Air Force Requirements Oversight Council to ensure they align with Air Force strategic priorities. Currently, the Air Force is working on three FCCs: the High Velocity Penetrating Weapon

(HVPW), Precision Airdrop (PAD), and Selective Cyber Operations Technology Integration (SCOTI).

The HVPW FCC was established to demonstrate critical technologies to reduce the technical risk for a new generation of penetrating weapons to defeat difficult, hard targets. This FCC is maturing technologies that can be applied to the hard target munitions acquisition including guidance and control, terminal seeker, fuze, energetic materials and warhead case design. This effort is developing improved penetration capability of hard, deep targets containing high strength concrete with up to 2,500 feet per second (boosted velocity) impact in a GPS-degraded environment. This technology will demonstrate penetration capability of a 5,000 pound-class gravity weapon with a 2,000 pound weapon thus increasing the loadout for bombers and fighters. Testing in 2013 has demonstrated warhead survivability and several sled tests are scheduled for the first quarter of Fiscal Year 2014.

The PAD FCC was commissioned in 2011 in response to a request from the Commander of Air Mobility Command for technologies to improve airdrop accuracy and effectiveness while minimizing risk to our aircrews. The Air Force Research Laboratory, Aeronautical Systems Center, and Air Mobility Command members established a working group to explore all aspects of the airdrop missions from re-supplying our warfighters in the field to providing humanitarian aid to people in need across the globe. To date, PAD FCC efforts have focused on: early systems engineering analysis to determine major error sources, data collection, flying with crews, wind profiling, designing high density pallet rollers, and designing modeling and simulation (M&S) activities. We expect demonstrations to begin in late calendar year 2013.

The SCOTI FCC is executing smoothly toward providing cyber technologies capable of affecting multiple nodes for the purposes of achieving a military objective. SCOTI directly meets the needs of a major capability area in the Air Force Cyberspace Superiority Core Function Master

Plan and provides a non-kinetic alternative to an adversary's operations. The standardized delivery platform being developed is scheduled to be complete in Fiscal Year 2013 and will serve as a baseline for current and future integrated cyber tools. The SCOTI stakeholders signed the finalized Technology Transition Plan in March, clearly identifying how SCOTI is expected to transition to the warfighters for operational use. SCOTI is on track to be delivered to the Air Force Life Cycle Management Center in Fiscal Year 2013 for integration with additional mission software, and Initial Operational Capability can be achieved as early as Fiscal Year 2016. In the past year, the stakeholders also completed SCOTI's Test Master Plan, and warfighters from the 166th Air National Guard conducted system-level tests on two development spirals of SCOTI technology with positive results. SCOTI is on track to meet all eight of its technical performance measures and provide the desired capability to the warfighter.

To ensure these FCCs and other advanced technology development efforts are postured for successful transitions to warfighting capability, the Air Force is continuing deliberate efforts to better align S&T planning, technology transition planning, and development planning. The linkages between these planning activities are critical to initiating acquisition programs with more mature technologies and credible cost estimates, and we are mandating this linkage in new Air Force policy.

The Air Force is also engaging small businesses through the Rapid Innovation Fund (RIF) to rapidly insert innovative technologies into acquisition programs that meet critical national security needs. In the first year (Fiscal Year 2011), the Air Force solicited innovative technologies in five broad thrust areas for this program: 1) Rapid Fielding to Support Overseas Contingency Operations, 2) Cyberspace Superiority and Mission Assurance, 3) Improved System Sustainment, 4) Power Generation and Energy for Platforms and 5) Joint Urgent Operational Needs (JUON) with an Air

Force interest. After receiving 729 white paper proposals from vendors in 44 states, the Air Force awarded 46 contracts, all of which went to small businesses.

We have experienced a similar reaction from industry to our Fiscal Year 2012 RIF broad agency announcement which solicited innovative technologies from more than 40 thrust areas submitted by the Air Force's Program Executive Offices (PEOs). The more than 700 white paper proposals received will be evaluated by a team from across the Air Force. We expect to make award notifications for the Fiscal Year 2012 RIF program in the spring of this year.

Overall, the Rapid Innovation Fund presents an opportunity to transition innovative technology into Service programs. The Rapid Innovation Fund provides a vehicle for businesses (especially small businesses) to easily submit their innovative technologies where they feel it will best meet military needs. The Air Force benefits by having the ability to evaluate proposed innovative technologies against critical needs and selecting the most compelling for contract award.

Through the Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) Program, the Air Force continues to garner the creative, innovative, and entrepreneurial spirit of small businesses to solve many technological problems. In that regard, we are pleased that the SBIR program was reauthorized through 2017 and many of its provisions expanded or made permanent. As we implement the provisions of the reauthorization, we intend to collaborate with other Federal agencies, where practical, to ensure that our processes are streamlined, efficient, and that small businesses continue to be a major driver of high-technology innovation and economic growth in the United States.

CONCLUSION

Our emphasis areas reflect our re-focused S&T portfolio given budgetary challenges and the Defense Strategic Guidance. I believe these areas also reflect the promise of future warfighting capability enabled by the technologies that will be developed with Air Force S&T Program

investment. We recognize that these challenges will not disappear tomorrow, and that is why we have improved our processes to make better investment decisions and to capitalize on these investments to efficiently deliver capability to our warfighters. We continue to institutionalize these initiatives in our policies and procedures across the Air Force. The S&T portfolio we present to you today, after all, is the genesis of our warfighting capability of tomorrow. Our Airmen and our Nation are depending on it!

Chairman Thornberry, thank you again for the opportunity to testify today and thank you for your continuing support of the Air Force S&T Program.



BIOGRAPHY

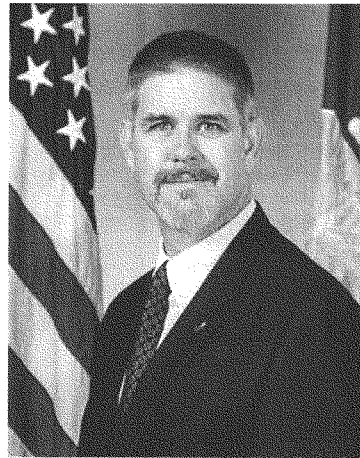
UNITED STATES AIR FORCE



DR. DAVID E. WALKER

Dr. David E. Walker, a member of the Senior Executive Service, is Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C.

Dr. Walker is responsible for preparing policy, guidance, and advocacy for the Air Force's annual \$2 billion science and technology program. He provides annual testimony to Congress, technical advice and counsel to the Air Force Acquisition Executive, and the Air Force's science and technology recommendations to the Office of the Secretary of Defense. In addition, Dr. Walker is responsible for overseeing a broad range of engineering and technical management policy spanning systems engineering; environmental safety and occupational health; industrial preparedness; and functional management of more than 14,000 military and civilian scientists and engineers.



Dr. Walker retired from an active-duty Air Force career as a colonel in 2006. As a master navigator, he has more than 2,700 hours in 65 different types of aircraft including the RF-4C and the F-15E. He served in a variety of assignments in operations, developmental test and evaluation, science and technology and the Air Staff.

Prior to his current position, Dr. Walker served as Associate Deputy Assistant Secretary of the Air Force (Acquisition Integration), Washington, DC.

EDUCATION

1979 Bachelor of Science degree in aerospace engineering, University of Texas at Austin
 1980 Master of Science degree in aerospace engineering, University of Texas at Austin
 1984 Squadron Officer School, Maxwell Air Force Base, Ala.
 1991 Air Command and Staff College, Maxwell AFB, Ala.
 1994 Doctor of Philosophy degree in Aeronautical Engineering, Air Force Institute of Technology, Wright-Patterson AFB, Ohio
 1997 Air War College, Maxwell AFB, Ala.
 1999 Advanced Program Manager Course, Defense Systems Management College, Fort Belvoir, Va.
 2009 APEX Senior Executive Orientation Program, Washington, D.C.
 2010 Air Force Enterprise Leadership Seminar, Darden School of Business, University of Virginia, Charlottesville
 2011 CAPSTONE, National Defense University, Washington, DC
 2012 Senior Managers in Government, Harvard Kennedy School, Cambridge, Mass.

CAREER CHRONOLOGY

1. February 1980 - October 1980, Student, undergraduate navigator training and Tactical Navigation Course, Mather AFB, Calif.
2. October 1980 - June 1981, Student, RF-4C Replacement Training Unit, 33rd Tactical Reconnaissance Training Squadron, Shaw AFB, S.C.
3. June 1981 - May 1984, RF-4C Weapon Systems Officer, 38th Tactical Reconnaissance Squadron, Zweibrucken Air Base, West Germany
4. June 1984 - July 1984, Student, Squadron Officer School, Maxwell AFB, Ala.
5. August 1984 - June 1985, Instructor Weapon Systems Officer, 16th Tactical Reconnaissance Squadron, Shaw AFB, S.C.
6. June 1985 - June 1986, Student, Air Force Test Pilot School, Edwards AFB, Calif.
7. June 1986 - January 1987, Experimental Test Navigator, 6512th Test Squadron, Edwards AFB, Calif.
8. February 1987 - November 1988, Experimental Test Weapon Systems Officer, F-15 Combined Test Force, Edwards AFB, Calif.
9. November 1987 - July 1990, Executive Officer to the Commander, Air Force Flight Test Center, Edwards AFB, Calif.
10. August 1990 - June 1991, Student, Air Command and Staff College, Maxwell AFB, Ala.
11. June 1991 - June 1994, Doctoral Student, Air Force Institute of Technology, Wright-Patterson AFB, Ohio
12. July 1994 - May 1995, Chief, Instructor Training, Curriculum Development, USAF Test Pilot School, Edwards AFB, Calif.
13. May 1995 - July 1996, Deputy Commandant, Air Force Test Pilot School, Edwards AFB, Calif.
14. July 1996 - June 1997, Student, Air War College, Maxwell AFB, Ala.
15. July 1997 - June 1998, Deputy Chief, Common Systems Division, Directorate of Global Power Programs, Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.
16. June 1998 - August 1999, Chief, Agile Combat Support Division, Directorate of Global Power Programs, Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.
17. August 1999 - June 2001, Director, Air Vehicles Directorate, Air Force Research Laboratory, Wright-Patterson AFB, Ohio
18. June 2001 - July 2003, Commander, 412th Operations Group, Edwards AFB, Calif.
19. July 2003 - July 2006, Vice Commander, Air Force Research Laboratory, Wright-Patterson AFB, Ohio
20. July 2006 - September 2008, Director, Material and Manufacturing Directorate, Air Force Research Laboratory, Wright-Patterson AFB, Ohio
21. September 2008 - May 2011, Associate Director of Programs, Deputy Chief of Staff for Strategic Plans and Programs, Headquarters U.S. Air Force, Washington, D.C.
22. May 2011 - August 2012, Associate Deputy Assistant Secretary of the Air Force (Acquisition Integration), Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.
23. August 2012 - present, Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering), Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.

AWARDS AND HONORS

Meritorious Executive Presidential Rank Award
 Associate Fellow, American Institute of Aeronautics and Astronautics
 Legion of Merit with two oak leaf clusters
 Meritorious Service Medal with two oak leaf clusters
 Air Medal
 Air Force Commendation Medal
 Air Force Achievement Medal
 Distinguished graduate, ATC Commander's Cup, and Ira Husek Flying Trophy, Undergraduate Navigator Training
 Top Gun, Tactical Navigation Course
 Distinguished Graduate, RF-4C RTU
 Distinguished Graduate and Outstanding Contributor, Squadron Officer School
 Distinguished Graduate and Raymond L. Jones Award, USAF Test Pilot School
 Distinguished Graduate, Air Command and Staff College

(Current as of September 2012)

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Statement by

Dr. Arati Prabhakar

Director
Defense Advanced Research Projects Agency

Submitted to the

Subcommittee on Intelligence, Emerging Threats and Capabilities
United States House of Representatives

April 16, 2013

NOT FOR PUBLICATION UNTIL RELEASED BY THE SUBCOMMITTEE

Chairman Thornberry, Ranking Member Langevin, Members of the Subcommittee, thank you for the opportunity to testify before you today. I am Arati Prabhakar, Director of the Defense Advanced Research Projects Agency (DARPA).

Three major factors drew me back to DARPA last summer after 19 years in other roles. The first was DARPA's disproportionately large impact on our current national security and technology capabilities. The second was the challenge of driving the technologies that will be cornerstones of our national security in the complex world we face in the years ahead. And the third was the privilege of leading this unique Agency, filled with people who come to work each day in vigorous pursuit of our important mission.

Today I'd like to tell you about each of these aspects of DARPA. I will include a discussion of our objectives and strategies, specific areas of investment, and our budget in the President's Fiscal Year (FY) 2014 request.

The starting point for our discussion today is the future security of the United States. We all understand the world is complex and changing in ways that will pose new threats to our national security. We all understand that resources will be constrained as we reshape defense budgets. But U.S. security capabilities must remain second to none despite these uncertainties and pressures. New technology has consistently created better options for our leadership - and better security outcomes for our Nation. Today, it is vitally important to continue to focus on the technology investments that will lead to a new generation of national security capabilities for our future. This commitment is reflected in the President's budget request for DARPA in FY 2014.

Before turning to DARPA itself, I'd like to set the context for our Agency in our Nation's research and development (R&D) efforts. DARPA is a projects agency, and we accomplish our objectives through deep engagement with companies, universities, Department of Defense (DoD) and other labs. Our success hinges on having a healthy U.S. R&D ecosystem. Within DoD Science and Technology (S&T) efforts, our role is to invest in high-payoff opportunities that often require taking significant risk. We work closely with our colleagues in the Service S&T organizations, sometimes building on their early research and drawing on their technical expertise, and often relying on them to help us transition successful results to military use.

DARPA's Impact

DARPA's recent transitions won recognition last fall when then-Secretary of Defense Leon Panetta gave the Agency the Joint Meritorious Unit Award, recognizing numerous contributions for the war effort. The award singles out the "creative intellect and keen expertise" that delivered "innovative cutting-edge technology to save lives and improve mission success amidst constantly evolving threats." Responding to urgent needs from troops on the ground, DARPA created and fielded a wide range of highly effective tools. These included a system that delivered three-dimensional views of the battlespace to operational and intelligence users, a radar pod to track threat vehicles and dismounted personnel, a radio system capable of interoperable communications and large data transmissions, a detection system that assesses blast exposure and medical risk to personnel, and a framework for the analysis of large amounts of data that provided unique and valuable insights to help answer key strategic and operational questions.

DARPA program managers, staff, and our partners were all excited to receive this recognition for what we work towards every day: creating new technological solutions and transitioning them into practice.

Because DARPA's enduring mission is to change the game in our favor when it comes to U.S. security capabilities in a rapidly shifting global context—and to do that by creating surprise for our adversaries and preventing surprises to our own forces—our warfighters long have depended upon many military systems that originated in earlier DARPA work. Aircraft with stealth capabilities, unmanned aerial vehicles (UAVs), night vision for our warfighters who now essentially “own the night” largely because of infrared imaging, the seemingly omnipresent global positioning satellite (GPS) capabilities for navigation and precision guided weapons, an arsenal of advanced communications and computing capabilities, and advanced intelligence, surveillance, and reconnaissance (ISR) are all well known and publicized examples. The list goes on and on, and it includes revolutionary changes in how the world thinks about important areas of science and technology, including information technology and materials science. The list also includes some elegant and important advances that do not get public attention by the nature of their applications. Simply put, our military has taken DARPA-initiated advances and used them to change warfighting dramatically. This is how we keep the scales tipped in our direction.

Looking to the Future: Technologies for the Next Generation of National Security

Today, as the Nation moves to the end of the active engagements of the last many years, it is time to look ahead and ask the fundamental questions for DARPA's mission. How do we create highly effective options for our future leaders in the face of the national security challenges of the coming decades? How do we dramatically change warfighting, once again changing the game in our favor faster than others can respond? How will we deter and defeat the many kinds of threats that many kinds of actors around the globe will attempt?

DARPA's new framework, captured in a document transmitted to this committee recently along with the President's FY 2014 budget request, describes how we think about this all-important question. “Driving Technological Surprise: DARPA's Mission in a Changing World” places great importance on the rapidly changing context in which our military leaders, warfighters, and DARPA now are operating. It explains how we anticipate, explore, and achieve the concepts and technology on which the Nation's future deterrent and defense capabilities depend. I will draw in part on that framework in my testimony.

The United States has seen great change that has affected our civilian and defense capabilities, positioning, and plans that challenges us every day. There is nothing new about needing to deal with changes in our adversary's capabilities. That is a big part of the history of armed conflict and its prevention or successful execution.

Today's Environment and DARPA's Strategic Objectives

But today's environment is different from the past. First, the Nation faces complex security challenges. Some are very real and some are potential in nature—but all demand viable options

for our Nation's leadership. We are finishing a counterinsurgency operation and building local security capabilities in Afghanistan. An array of diplomatic, intelligence, and possible military measures must be ready if needed to address nuclear uncertainties posed by Iran and North Korea. Our government and private networks deal with the growing onslaught of more capable and frequent cyber-attacks from many sources on an ongoing basis. Potential adversaries are deploying sophisticated capabilities to contest our ability to project military power. And a look into the future only adds uncertainty. The proliferation of nuclear, chemical, and biological weapons of mass destruction or terror; the flare-up of tensions among nations in hot spots around the world; growing pressures in the urbanizing developing world; and the globalization of technology and new R&D are all trends we can see.

This shifting, unpredictable national security environment demands a wide range of capabilities for the future and the agility to both anticipate and respond to whatever comes.

I want to underscore a point: the technology base upon which our military systems are critically reliant is highly globalized. This introduces potential vulnerability in both the assurance of supplies and the security of the supply chain. At the same time, other players have the same access to this supply of highly capable components, and many have used them to quickly develop weapons systems with highly advanced capabilities. This pattern of globalization, wide availability, and growing vulnerability pervades most of the core technologies upon which our defense systems rely. Our challenge is to create an edge for U.S. national security purposes in this environment.

The second significant factor driving our objectives going forward is the possibility of a change in public investment for national security. Because DARPA's prime directive is to prevent strategic surprise and enable our superiority, we must consider what will be required to meet the Nation's security needs even in these circumstances.

The uncertainties we face—threat uncertainties and fiscal uncertainties—do not change the fact that the Nation relies on DoD to deter war and protect the security of our country, and DARPA's role here is vital.

DARPA's Approach

Our first two primary objectives are:

- 1) Demonstrate breakthrough capabilities for national security, and
- 2) Catalyze a differentiated and highly capable U.S. technology base – critical to achieving the first objective.

Several approaches shape our thinking as we attack the need for breakthrough capabilities for national security:

- 1) *Game-changing new systems technologies*. Today's warfighters rely on systems from aircraft to navigation to communications that trace their history to earlier DARPA work. Looking ahead, some of these may become vulnerabilities as sophisticated adversaries also understand how crucial these systems are to warfighting. So, DARPA seeks to create the next generation of new capabilities that once again changes the game in our favor faster than others can respond.

- 2) *Layered, multi-technology war fighting concepts.* Modern warfighting is too complex for a single new capability to deliver sustained superiority across a variety of scenarios. But combining multiple technology advances by layering and integrating them can lead to a revolution in capabilities. Looking ahead, we can imagine coordinated local position, navigation, and timing (PNT); adaptive electronic warfare; manned and unmanned systems working in harmony; tactical cyber effects; and advanced ISR – all woven together in ways that create decisive surprise in tomorrow’s conflicts.
- 3) *Adaptable systems and solutions.* While military technology and weapon systems have continued to evolve and mature over time, our military engagements of the last 20 years have been fought with systems developed largely for Cold War scenarios. Our warfighters have had to adapt for the realities on the ground. Today when we consider future engagements, we can more readily imagine a host of diverse environments and adversaries. In an uncertain world, adaptability is critical. We won’t always know what we will need for tomorrow’s battle, and our adversaries will change their tactics and technologies over time. So systems that can be readily upgraded and adapted in real time to changing surroundings and conditions will play an important role.
- 4) *Innovation to invert the cost equation.* Today we seek to use innovation to radically invert the cost dynamic. How can we impose more cost on our adversaries and less on ourselves, thereby increasing our deterrent? Can innovative systems architectures, autonomy, adaptability, and new processes offer new possibilities? These approaches may allow us to reinvent development, production, logistics, operations, and maintenance in ways that radically change the cost equation.

Two themes shape our efforts to catalyze a differentiated and highly capable U.S. technology base:

- 1) *Exploiting and transcending commercially available technologies.* We seek to be the best user of globally available technologies – to use them with greater creativity to solve problems more quickly, efficiently, and flexibly. This means novel systems architectures as well as integrating specialized niche technologies with commercially available components to create unique solutions.
- 2) *Catalyzing new national technology capabilities.* Entirely new technologies open the door to national security applications that can’t even be imagined beforehand. We recognize that many of these technologies will also globalize. But the time advantage to the United States, if we pursue them first, can be substantial and make all the difference. We approach this challenge in several ways:
 - Exploring new technology possibilities from fertile basic and interdisciplinary research. Universities, government labs, and private R&D organizations are bubbling with intriguing new research across many disciplines and new interdisciplinary fields. Some hold the seeds for the next technology revolution. We actively search for these promising activities and explore where these new insights might lead.
 - Building foundational technology infrastructure and communities. DARPA has a long history of building technology infrastructure that becomes the foundation for wide arrays of applications. Today, we are using the same approach in new fields. Our programs create the tools, techniques, and communities that scale well beyond the period of our investment.

- Demonstrating the new capabilities that technology enables. Changing minds about what's possible rarely happens just through writing papers and reports. Projects that build prototypes show how technical breakthroughs enable new capabilities.

The President's FY 2014 Budget

The President's FY 2014 budget proposal for DARPA is \$2.865 billion. This is on par with the \$2.817 billion originally budgeted for DARPA in FY 2013, but has now been reduced to \$2.785 billion following congressional action. The FY 2013 budget has been further reduced by approximately \$223M as a consequence of sequestration.

Before discussing our FY 2014 plan, let me explain our FY 2013 status under sequestration. As I'm sure you know, sequestration is having a significant effect on our work during this fiscal year. At DARPA, we have prioritized within each Program Element to execute cuts as intelligently as possible, but with cuts of this size there are real consequences. We are projecting up to 14 days of furloughs for our civilian government employees, and we are delaying or eliminating programs as a result of the 8% cut in each Program Element. While the planned furlough days are of course a financial concern for our employees, our people are also deeply frustrated they will not be allowed to do their jobs on these days. This unfortunate message makes it that much harder to recruit and retain the stellar individuals we need to accomplish our mission. Programs across the Agency are affected by the sequestration cuts. Two examples include Plan X and the Microtechnology for Positioning, Navigation and Timing (microPNT) program. Plan X, which aims to integrate cyberwarfare and kinetic fighting, is being cut by 43% in FY 2013, delaying its start by five months. The microPNT program, which is developing the capability for precise, self-contained PNT in severe environments, will see a 9% cut, delaying testing with the Air Force and driving additional schedule extensions.

Looking forward, the proposed FY 2014 budget would provide us with resources to address or—in some cases, begin to address—our essential programs. I'd like to highlight a number of areas that range from particular military systems to broader, enabling technologies.

Cyber foundations for a scalable new trajectory: DARPA's cyber programs tackle two aspects of this broad challenge that are redefining the rules of warfighting. One is to create the capabilities that will allow us to move beyond today's "detect and patch" approach to a more fundamental defense of our cyber systems. We aim to provide cybersecurity and survivability solutions that enable DoD information systems to operate correctly and continuously even when attacked. The second aspect focuses on cyber effects in tactical warfighting scenarios. We can readily imagine a future in which cyber warfare is fully integrated with kinetic warfare. DARPA's cyber offense efforts aim to create the tools that bridge these domains, for example, by providing simulations of cyber effects, battle-damage assessments, and layers of authority and control.

Cost-effective space systems in a newly contested environment: Unsustainable cost growth has materially affected the development of future U.S. capabilities in the all-important environment of space upon which DoD, the intelligence community, and commercial sectors rely. DARPA is tackling these challenges by focusing on affordable routine access, agile systems development at lower cost, survivable and resilient systems, disaggregated and simplified systems, and a holistic

approach to space situational awareness. For example, one DARPA effort is striving to drive the cost of space access down to \$1 million per launch and increase the tempo to single-day turnarounds. Creatively—and ambitiously—another program is exploring cooperatively harvesting and reusing valuable retired satellite components to build an entire new space system in geosynchronous orbit. If successful, this would be a major contribution to achieving the goal of reducing today's overall satellite system cost by 90 percent.

Air Dominance: Our forces have had the upper hand in air combat for many years now. But as others use globally available technologies to build new and sophisticated systems, resting on our laurels would be a dangerous course. With the support and endorsement of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Frank Kendall, DARPA has teamed with the Air Force and Navy to study the challenges of air dominance for the next generation. The working group is investigating how we can build on our current capabilities with new technologies and concepts, inverting the cost equation to force future adversaries to spend much more to counter than we do to field and employ. The team is taking a broad, integrated approach, looking at electronic warfare and sensing across the electromagnetic spectrum, communications and networking, space, cyber, weapons, and platforms. We anticipate this study effort will lead to new initiatives, with the ultimate goal of ensuring the United States continues its air superiority in the 2020-2050 timeframe.

Countering Weapons of Mass Destruction (WMD): We are pursuing efforts to increase efficacy and accelerate the timeline for bioweapon threat response, including novel techniques that will enable the human body to directly manufacture its own vaccines, bypassing traditional vaccine manufacturing processes that can take months. In addition, we are studying current challenges in countering chemical and nuclear WMD threats. For example, we are investigating a defense-in-depth approach, combining novel detection methods and big data intelligence analytics to achieve a more robust, layered solution. We are also looking into new medical countermeasures for increasing the survivability of victims of acute radiation poisoning.

Position, navigation, and timing (PNT) capabilities beyond our critical reliance on GPS: DARPA's recent programs in PNT originally sought to take GPS-like capability to the places where GPS currently does not operate, such as indoors, underwater or underground. As concerns surfaced about our critical dependence on GPS, those initial investments are starting to create GPS alternatives, as well as new enablers for future military systems. We have developed micro-PNT technologies and are transitioning them to use. We are developing new inertial measurement units and clocks that use atom interferometry for very long duration missions, as well as techniques that use available signals – from television, radio, cell towers, or even lightning – to augment or replace the location information that GPS currently provides. And in keeping with the drive for adaptability, our new approach to full navigation systems integration could provide rapidly configurable solutions for the many types of platforms that require advanced PNT.

Electronic warfare (EW) to counter and move beyond adversaries' advancing capabilities: We face important challenges as we seek to protect our assets and deploy EW capabilities. Not the least of these is the reality that 90 percent of the electronics needed in an EW system can now be bought commercially. DARPA is attacking these challenges. For instance, DARPA is developing

a new architecture for the radar antenna arrays with which ships and planes transmit and receive radar pulses. The goal is to make them in modular fashion, obviating the need for unique designs for each new application and permitting new and multiple modes of use. This has the potential to drive future radar costs down significantly, while simultaneously improving performance. Another challenge, and there are many, is that the system performance of many radios and radar units is constrained by the performance limits of electronic components inside those units. DARPA aims to drive technology capabilities well beyond commercial specifications and to extend important electronic components to performance regimes unreachable by commercial technology.

Engineering biology tools to engineer microorganisms for materials with new properties:

Engineering biology is emerging as a new field as researchers across multi-disciplinary labs have started to design and construct genetic pathways, networks, and systems to harness the powerful synthetic and functional capabilities of biology. We can see the potential to develop new and transformative materials, sensing capabilities, and therapeutics. But synthetic biology today is still a multi-year, ad hoc, trial-and-error process constrained to a limited number of simple products. DARPA's investments in the Living Foundries program are developing the tools and technologies to create a new engineering practice, speeding the biological design-build-test cycle and the rate at which we realize novel products and capabilities. Drawing upon and building on the research base, these efforts will begin to create the foundational infrastructure for engineering biology. Some of the first outputs may include new materials and medicines such as antifungals, lubricants, and energetic materials. Beyond these are a new generation of products with properties we can only imagine today.

Big data capabilities to draw insight from multiple data sources: Exponential improvements in computing power, network bandwidth and storage density combined with ever more pervasive sensing and measurement technologies give us enhanced tools for drawing information and insights from massive, heterogeneous data sets. In the national security realm, harnessing big data offers special challenges. National security often involves actors with a vested interest in remaining unobserved. Data sets may be corrupted, incomplete, or disaggregated to the point that sophisticated technologies are required for cleanup. Data sets may be multimodal, real time-streamed, or on a scale for which storage isn't feasible and requires new processing approaches. Moreover, in many national security applications, inferences must be drawn, relationships deduced, or anomalies detected working solely from data sets that are weak proxies for the underlying quantities of interest. The varied ways in which data are gathered pose challenges in fusion. And while the cost of investigating false alarms is often high, the consequences of a missed detection are even greater. These challenges are being addressed across DARPA's big data portfolio. The effort begins at the basic science level and also addresses fundamental computational issues such as novel algorithm design, natural language processing, and architectures for efficient processing of streamed data. At the other end, DARPA is working closely with national security agencies on operational data to ensure continuous transition of tools as programs progress.

Brain function research: DARPA plans to build on its past and ongoing research to help advance a new understanding of brain function to treat injury, create new brain-machine interfaces, and inspire new algorithms and hardware. Earlier this month the President announced an initiative to

revolutionize our understanding of the human brain. DARPA's brain function research will play an important role in the initiative, with the goal of understanding the dynamic functions of the brain and demonstrating breakthrough applications based on these insights. DARPA aims to develop a new set of tools to capture and process dynamic neural and synaptic activities, and explore ways to dramatically improve the way we diagnose and treat warfighters who are suffering from post-traumatic stress, brain injury and memory loss.

I want to note that we pursue technologies like these because of their promise, but we understand that in this pursuit, we might be working in areas that raise ethical, legal, security, or policy questions. Here, our job is twofold. We must be fearless about exploring new technologies and their capabilities; this is our core function and our Nation is best served if we push these frontiers ahead of other countries. At the same time, we must raise the broader societal questions and engage those who can address them. We ensure our work adheres to laws and regulations. In new and uncharted territory, we reach out to a variety of experts and stakeholders with different points of view. In many instances, technology solutions can be part of the answer to new concerns. But we recognize that at their heart, these are societal questions that require a broader community be engaged as we explore the technological frontier.

A wide array of other DARPA programs also reflects our investment approaches for breakthrough systems and technologies. They include programs in maritime and undersea systems, hypersonics, communications, ISR, robotic systems, innovative manufacturing technologies, adaptable sensor systems, and unconventional computing platforms. More broadly, we also invest in early-stage research efforts across physics, materials science, mathematics, and interdisciplinary fields with the potential for future technological applications. The President's FY 2014 budget includes funding for this critical work.

Keeping DARPA Robust and Vibrant

To accomplish our vital mission, it is essential that we keep DARPA robust and vibrant. So our third objective is to *ensure a highly functional environment and the foundation for a strong culture*.

With just 210 government employees we carry out 250 programs across five technology offices. How is this possible? In addition to having a cadre of very capable support functions and contractors, we rely heavily on active engagement with the technical community and users, as I emphasized earlier. Our success hinges on our ability to work with tiny companies to universities and major contractors to labs of every stripe. It hinges on our relationships with and the work of the users of our results across DoD.

DARPA's program managers are the core of our organization, and they are stellar. Each is a leader who brings to DARPA an adventurous spirit and a deep conviction that his or her technology vision will change the world. They come to DARPA because this is the place that gives them the opportunity to take breakthrough technologies to fruition. Our program managers generally serve 3 to 5-year terms, leading to a constant flow of new people and fresh views.

That is why our hiring authorities are so important to us. DARPA uses a dynamic mix of hiring and retention authorities enabling the Agency to continue to hire and retain the nation's most qualified technical experts from industry, academia, and the private sector with speed and flexibility not allowed by standard civil services processes. Moving forward, maintaining and fostering a robust and vibrant DARPA hinges on our continued ability to recruit and retain the people who will meet the challenges of an ever-changing threat environment.

I would like to thank the Subcommittee for its continued support of DARPA's hiring authorities. It has been enormously helpful to us, and we simply could not attain our high caliber staff without it.

From Basic Science to Military Advantage: How a Clock Could Make a Difference

Let me conclude with a specific example of how we do our work – one of the numerous individual efforts underway in our portfolio today.

Earlier in my testimony I cited our important work on position, navigation, and timing systems as we strive to develop capabilities beyond what GPS systems offer us today. Position and time is oxygen for our warfighters, but GPS signals can be degraded or denied by adversaries who aim to jam or spoof our signals.

One of our novel PNT approaches captures how DARPA's ability to think outside the box, and our constant search for new ideas and surprises, can lead to the hard-nosed practical solutions we must have for technological superiority in national security.

Frequency and timing devices are essential components in modern military systems. The stability and accuracy of these devices affect the performance of communication, navigation, surveillance, and missile guidance systems. Atomic clocks are at the core of many of these systems, either directly or by synchronization with a master clock.

DARPA is now building on exquisite Nobel Prize-winning science conducted in the mid-1980s that enlisted lasers to cool and trap atoms, and work from the late 1990s to precisely read out these atomic states. Although it was far from apparent then, these fundamental physics discoveries, and the basic science work that followed over the next two decades, now holds the promise of allowing DoD to develop a dramatically improved atomic clock device.

But the best atomic clocks operate only in lab environments – large rooms with scientists to tend their complicated laser systems. That severely limits practical applications. Still, DARPA recognized the promise that timekeeping-related advances held for military uses. So we aimed to develop simpler clock architectures based on the initial Nobel Prize research and related work that would still meet our needs.

That is much, much easier said than done, of course. After some very hard work by a very talented team, we are now developing a shoebox-sized optical atomic clock that offers dramatic reductions in size, weight and power requirements. It aims for unheard of accuracies for a device of its size (within one billionth of a second over the course of a year). The payoffs will be huge if

we are successful: secure data routing, communication systems that are insensitive to jamming, high-resolution coherent radar, and more reliable and robust global positioning. An accurate local clock would be one critical enabler of continued operation of military systems in the absence of GPS.

If successful, in combination with other technologies we are working on, this new clock developed under the QuASAR program will lead to a new set of PNT technologies – a pillar of the next generation capabilities that DARPA is building. In short, this device, along with the many other technologies we are driving, can transform war fighting for our future needs. That would be a true game-changer – and that, after all, is what DARPA is all about: changing the game in our Nation's favor.

Thank you for your support of DARPA, and for allowing me to testify before you today. I look forward to your questions.



ARATI PRABHAKAR
DIRECTOR
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Arati Prabhakar is the director of the Defense Advanced Research Projects Agency.

Dr. Prabhakar has spent her career investing in world-class engineers and scientists to create new technologies and businesses. Her first service to national security started in 1986 when she joined DARPA as a program manager. She initiated and managed programs in advanced semiconductor technology and flexible manufacturing, as well as demonstration projects to insert new semiconductor technologies into military systems. As the founding director of DARPA's Microelectronics Technology Office, she led a team of program managers whose efforts spanned these areas, as well as optoelectronics, infrared imaging and nanoelectronics.

In 1993, President William Clinton appointed Dr. Prabhakar director of the National Institute of Standards and Technology, where she led the 3,000-person organization in its work with companies across multiple industries.

Dr. Prabhakar moved to Silicon Valley in 1997, first as chief technology officer and senior vice president at Raychem, and later vice president and then president of Interval Research. From 2001 to 2011, she was a partner with U.S. Venture Partners, an early-stage venture capital firm. Dr. Prabhakar identified and served as a director for startup companies with the promise of significant growth. She worked with entrepreneurs in energy and efficiency technologies, components for consumer electronics, and semiconductor process and design technology.

Dr. Prabhakar received her Doctor of Philosophy in applied physics and Master of Science in electrical engineering from the California Institute of Technology. She received her Bachelor of Science in electrical engineering from Texas Tech University. She began her career as a Congressional Fellow at the Office of Technology Assessment.

Dr. Prabhakar has served in recent years on the National Academies' Science Technology and Economic Policy Board, the College of Engineering Advisory Board at the University of California, Berkeley, and the red team of DARPA's Defense Sciences Research Council. In addition, she chaired the Efficiency and Renewables Advisory Committee for the U.S. Department of Energy. Dr. Prabhakar is a Fellow of the Institute of Electrical and Electronics Engineers, a Texas Tech Distinguished Engineer, and a Caltech Distinguished Alumna.

**WITNESS RESPONSES TO QUESTIONS ASKED DURING
THE HEARING**

APRIL 16, 2013

RESPONSE TO QUESTION SUBMITTED BY MR. NUGENT

Dr. WALKER. The Counter-Electronics High Power Microwave (HPM) Advanced Missile Project (CHAMP) was an Air Force science and technology (S&T) Joint Capabilities Technology Demonstration (JCTD) which successfully demonstrated the effects of an HPM weapon on a wide range of military-relevant electronic equipment in a realistic environment. S&T develops and demonstrates technology that can be transitioned to the system development/procurement community.

As this was an S&T demonstration, the JCTD was limited in scope and did not account for weapon survivability and effects delivered in an operationally relevant threat environment. A CHAMP JCTD Military Utility Assessment is currently being drafted by U. S. Pacific Command (USPACOM). The Air Force will use this assessment and any additional information/data from the demonstration to feed the Air Force's Non-Kinetic Counter Electronic (NKCE) weapon concept of using HPM technology to affect real world electronic equipment in an operationally relevant threat environment. The Air Force is completing the NKCE Comprehensive Concept Analysis (CCA) in FY14. The CCA will define the technological characteristics required to integrate HPM technology into a weaponized platform and be survivable in an operationally relevant threat environment long enough to deliver the intended effects. CHAMP, along with other potential solutions, will be part of NKCE Analysis of Alternatives (AoA) notionally scheduled to take place during FY15. If the warfighter (e.g. USPACOM) determines there is an urgent need that CHAMP could support, there is a separate process to support that need. As of now there has not been such a request.

FY13 and FY14 funds supporting these analyses has been requested in a system development and demonstration program element (PE) 0604429F, Airborne Electronic Attack. [See page 22.]

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

APRIL 16, 2013

QUESTIONS SUBMITTED BY MR. THORNBERRY

Mr. THORNBERRY. In your testimony, you mentioned the benefits of the direct hiring authority provided to the Science and Technology Reinvention Laboratories. Are there impediments to wider use of this authority? If so, what can be done to improve the situation?

Mr. SHAFFER. Yes, there are impediments/limitations to direct hiring authorities for our labs. One impediment is that direct hiring of only scientists and engineers with advanced degrees is allowed. This impediment prevents us from directly hiring scientists with undergraduate degrees. Nevertheless, preliminary reports from lab directors indicate positive results for the hiring of talented and highly qualified university graduates into our laboratories who may have taken offers from other organizations if not for the new expedited processes enabled by STRL authorities. However, the sequester and associated budget issues are expected to have a negative impact on both hiring and retention of lab S&Es. Regarding impediments to hiring, ancillary effects due to the current budget shortfalls may be hurting our workforce. The prolonged pay freeze, travel restrictions, limitations on conference attendance, and potential reductions in force are concerns. Given the fact that our labs are the Department's technical base, these factors may degrade our technical capability for the foreseeable future.

Mr. THORNBERRY. In your testimony, you stated that the Department is in the process of quantitatively determining perceived shortfalls in prioritizing Service military construction (MILCON) projects and how DOD labs compete in the process. But this isn't a new problem, so why are you just now studying it? Is the current funding limit for minor military construction sufficient for the needs of the DOD labs? Should it be increased? If it was, what might the impact be on other MILCON activities?

Mr. SHAFFER. This issue remains a topic of interest to my office, and we have given attention to this issue for years. Our last report submitted to Congress in FY2011, "DOD Laboratory Recapitalization and Sustainment Issues," in response to Senate Report 111-035, documented status of lab infrastructure including investments from the BRAC 2005 construction projects. Our current efforts are in partnership with the White House Office of Science & Technology Policy's Committee on Homeland and National Security Infrastructure Subcommittee, which has representatives from Departments of Defense, Energy, Homeland Security and others involved with national security issues. A key goal of this group is to update federal security laboratory infrastructure physical status, funding, and funding mechanisms to develop policy recommendations for maintenance and improvement of labs. In addition, the Department submitted a FY 14 legislative proposal to increase the discretionary minor MILCON authorities from \$2M to \$4M per project.

The Department quantifies the status of physical infrastructure via determination of the Facility Physical Quality Rating (FPQR), which, on a scale of 0–100, depicts the capability of existing facilities as measured by a physical condition index. The Condition Index (CI) is a general measure of a constructed asset's condition at a specific point in time. Included in the measure of the CI, is the Functionality Index (FI) which relates the suitability of the physical asset to perform the functions for which the building is required. For prioritization of MILCON needs, the Services then determine an additional metric, the Mission Dependency Index (MDI) which represents Mission Criticality of the asset. The DOD goal for the FPQR is 80 for any building. If an asset is graded below this value, it then becomes a candidate for refurbishment or replacement. In response to the Office of Management and Budget, we are examining the FPQR of the Defense Laboratories. Preliminary results show our labs to have an overall FPQR of 80, which is an acceptable rating.

While our preliminary data analysis indicates that our laboratory infrastructure is in acceptable overall condition, we are concerned that there may be some cases where individual buildings leave some capabilities at risk, and more detailed analysis is required in those instances. To address this potential problem, we are initiating an analysis of several laboratory director identified buildings to determine whether there is indeed a MILCON problem not identified in a top level analysis.

Mr. THORNBERRY. The Assistant Secretary of Defense for Research and Engineering is tasked by directive as the principal staff assistant for biometrics. What are you doing to ensure biometrics remains an enduring DOD capability? What do you see as needed future capabilities to support biometrics?

Mr. SHAFFER. As the Secretary's Principal Staff Assistant (PSA) for DOD Biometrics, I see biometrics as an important contributor in support of the National Defense Strategy. The most important future capability DOD requires is an authoritative biometric storage and matching system tailored to support the Department's unique needs and operating environments. This system must use technologies to exploit poor-quality biometric images collected in austere locations; be capable of processing larger numbers of matches as DOD's use of biometrics grows; and, provide near real-time information to users operating in remote locations. Our staff is working with the Executive Agent for DOD Biometrics to develop a formal biometric acquisition program with enduring funding to achieve the key capabilities required for the future. We expect to begin fielding these systems by FY 2017. Over the past year, we have:

- Developed an updated policy to expand the use of biometrics from operations in Afghanistan and Iraq to all areas where DOD operates. The Department is also developing policy to enable force protection personnel to use biometric data to grant access to military facilities.
- Advanced data sharing between DOD and the Department of Homeland Security. Maximizing biometric data sharing between the Departments helps identify malign agents before they can do harm to the Homeland or to our overseas interests.
- Sponsored technology development in key biometric areas such as thin film fingerprint detectors, latent fingerprint processing and multispectral facial matching. These investments advance biometric capabilities and help maintain the relevancy of biometrics as an enabler across a range of military missions.
- Established the enduring use of biometrics at national-level organizations including the White House-sponsored National Science and Technology Council subcommittee on Biometrics and Identity Management; the National Security Staff (NSS) Interagency Policy Committee (IPC) on Information Sharing to Counter Terrorist Travel; and, the NSS IPC on Information Sharing and Access.

Mr. THORNBERRY. You mentioned in your testimony the importance of the special hiring authorities DARPA has, but you can also use authorities for IPAs (Intergovernmental Personnel Act) and HQEs (Highly Qualified Experts). Why have those not worked as well for DARPA?

Dr. PRABHAKAR. DARPA continues to use the IPA authority as often as practicable. However, as of September 2012, the IPA delegation allowing DARPA to set flexible and competitive salaries was rescinded and limiting conditions were imposed per Office of the Secretary of Defense for Administration and Management (DA&M) memorandum dated September 20, 2012. This has made utilization of the IPA authority more challenging and, at times, a non-option. As an example, we recently lost a highly talented candidate from a leading university because his salary far exceeded what DARPA is allowed to reimburse under existing guidance.

The HQE delegation was modeled in its entirety on DARPA's Experimental Hiring Authority first implemented in Section 1101 of the Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 (Public Law 105-261) as "Defense Advanced Research Projects Agency Experimental Personnel Management Program for Technical Personnel." The HQE authority is broader than the 1101 authority, applicable not only to those in the Science and Technology (S&T) community, but also to fields providing other expertise.

As first established, DARPA could use the HQE and 1101 hiring and retention authorities interchangeably. However, beginning February 2004, the Office of the Under Secretary of Defense for Personnel and Readiness (USD(P&R)) took steps to restrict and better manage the allocation of DOD-wide HQE positions, resulting in a process that made the HQE authority more challenging for DARPA to use. First, as established by Section 9903 of title 5, United States Code (U.S.C.), the DOD-wide cap for HQE appointments shall not exceed 2,500 positions. These 2,500 positions, in turn, are apportioned and managed by the Deputy Under Secretary of Defense for Civilian Personnel Policy (DUSD(CPP)). Second, OSD(P&R) reemphasized that HQE basic pay cannot exceed the maximum limit established by 5 U.S.C. 9903(b)(2), typically within the range from General Schedule 15 (GS-15) Step 1 (or equivalent) up to the statutory limit of Executive Schedule Level II, provided the Department's Pay and Performance Management System is certified by the Office of Personnel

Management (OPM) . More recent OSD(P&R) guidance further clarified the maximum compensation for HQE positions (to include basic pay and locality-based comparability payments) at \$165,300 . Finally, in the March 14, 2011 Office of the Secretary of Defense DOD efficiencies memorandum and the September 20, 2012 memorandum (effective at the beginning of FY13) the Office of the Secretary of Defense, Director of Administration and Management (DA&M) rescinded delegation of the HQE authority to defense agencies and approval authority for all HQE hires was centralized to the DA&M/Deputy Secretary of Defense level.

The DA&M centralized process for hiring HQEs includes serial coordination/approval from the following organizations:

- Assistant Secretary of Defense for Research and Engineering (ASD (R&E))
- Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L))
- Washington Headquarters Services (WHS) Human Resources Directorate (HRD)—Executive and Political Personnel
- Director of Administration and Management (DA&M)
- Under Secretary of Defense for Personnel and Readiness (USD (P&R))

Under this process, defense agencies are unable to extend a letter of offer to an HQE candidate until all five organizations coordinate on and approve an HQE hiring package. The hiring package must include candidate qualifications, project details, and compensation justification to include labor market conditions, work schedule, organizational needs, personal qualifications, experience, budget considerations, organizational equity and mission impact of work assignments. Each organization may take up to 3 weeks to coordinate on a hiring package.

With the centralization of the HQE hiring authority and the additional time required to staff, coordinate, and approve HQE positions, the utility of the HQE hiring authority for DARPA beyond FY12 has decreased. As a result, DARPA's reliance on alternative, more flexible hiring and retention authorities (namely IPA and 1101 authorities) has increased and DARPA does not envision hiring any additional HQE positions at this time.

QUESTION SUBMITTED BY MS. SANCHEZ

Ms. SANCHEZ. Project Pelican, which involved the construction and testing of an advanced demonstrator airship, has proved that it is possible to control buoyancy without ballast or other external assistance, a challenge has been a major hurdle for the development of airships for heavy lift purposes. I understand that these hangar demonstrations, which were conducted in Tustin, CA, in January, met all the objectives that were set for the program in 2008. NASA, which cooperated with DOD in the development of the advanced demonstrator, has rated Pelican's Technology Readiness Level at 6-7. As you know, General Fraser, Commander of TRANSCOM, told the Committee on March 6 that "Hybrid Airships represent a transformational capability bridging the long standing gap between high-speed, lower capacity airlift and low-speed, higher capacity sealift." He also said that the hybrid airship technology has the potential to fulfill "Factory to Foxhole cargo delivery." What are your plans to continue the effort to develop hybrid airships for heavy lift?

Do you intend to go forward with the development of a 66-ton payload version?

What can Congress do to keep this technology and move on to further operational vehicle development?

Mr. SHAFFER. From the outset, Pelican was intended to be a technology demonstrator rather than an airship prototype. In this capacity, Pelican demonstrated several subsystems that will add to DOD's collective knowledge of airship technologies and help inform future investment. The funded FY13 work will add technical rigor to the analyses of Pelican's sub-systems and exhaust Pelican's use as a technology demonstrator. ASD(R&E) does not, however, have plans to move forward with a 66-ton version. A larger version will have to be supported by a military department, which is responsible for equipping and fielding systems, and have to be affordable.

The information gained from Pelican and other recent airship projects will help the department determine whether continued larger scale, hybrid airship development is warranted. At this point there are no plans to build a large scale vehicle; however, the Department has set aside annual funding to study technologies required should a large scale airship project be initiated in the future.

Advances in hybrid airship technology have justified investigation of potential airship solutions to logistics and ISR missions; however, much of this technology is in its infancy and must be matured in a methodical and rational manner. Equities in potential heavy lift capabilities go far beyond military applications. After the testi-

mony cited above, Commander TRANSCOM also stated, "We encourage development of commercial technologies that may lead to enhanced mobility capabilities in the future." General Fraser's comments reflect OSD's intention to follow commercial airship development and collaborate with industry when appropriate.

QUESTIONS SUBMITTED BY MR. JOHNSON

Mr. JOHNSON. What concrete steps are each of your organizations doing to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs)? Is there more that Congress can do to help expand efforts with the HBCU/MSIs?

Mr. SHAFFER. We have taken several concrete steps to reinvigorate the DOD relationship with the Historically Black Colleges and Universities and minority-serving institutions (HBCU/MI) and appreciate the continuing strong Congressional support for this program. We point to four concrete steps:

1. The FY 2014 budget request added \$15M to the program to create three Centers of Excellence (COE) at HBCU/MI's. These COEs will be competitively awarded in the area of cyber, autonomy and data to decisions.
2. We held a successful workshop where we brought together HBCU researchers from over 30 universities and their technical counterparts in the DOD research offices in a forum that allowed the researchers to talk about their research and understand DOD research priorities. Communication both within the Department and between the DOD management and staff and HBCU/MI is central to the success of our efforts.
3. The ASD(R&E) communicated his expectations for the HBCU/MI relationship in a December 2, 2011, memorandum to DOD Components, "Reinvigorating Our Relationship with the Historically Black Colleges and Universities (HBCUs) and Minority-Serving Institutions (MIs)." For example, senior DOD managers have visited the Presidents of several HBCU/MI.
4. We recently developed, and sent to Congress, a plan that outlines actions to strengthen and expand the HBCU/MI program in the next 2 years. The plan builds on the activities already under way and furthers our efforts to enhance the HBCU/MI program.

Mr. JOHNSON. What concrete steps are each of your organizations doing to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs)? Is there more that Congress can do to help expand efforts with the HBCU/MSIs?

Ms. MILLER. The Army has a concerted effort in support of historically black colleges and universities and minority serving institutions HBCU/MSIs and they remain an important part of the Army's research base. The Army conducts targeted outreach to HBCU/MSIs to provide awareness of all funding opportunities and strongly encourages direct dialogue with technical points of contact to identify areas of common research interest. Additionally, the Army funds five centers of excellence at HBCUs through the Partnership in Research Transition Program, pursuing basic research with high potential for moving into applied research in areas with very high relevance to the Army, such as the development and optimization of structures leading to better force protection, the development of algorithms for standoff radar for landmine and improvised explosive device Detection, and research to better understand the socio-cultural content of African languages. Additional HBCU/MSI outreach efforts include using Intergovernmental Personnel Act agreements and faculty and student fellowships/internships to bring HBCU/MSI researchers into Army laboratories to conduct collaborative research, as well as Educational Partnership Agreements that provide student employment, curriculum development for all levels of education, and other support to the universities and students. Finally, the Army actively supports DOD-sponsored and other technical conferences and outreach events (to the extent permitted by current fiscal constraints) targeting HBCU/MSIs to ensure the widest possible awareness of Army/Department of Defense (DOD) research opportunities.

While we do not need any additional authorities in this area, it is important for Congress to continue to provide support for research and outreach activities with HBCU/MSIs in order to build institutional research capacity, encourage greater participation in DOD programs, strengthen their ability to provide excellence in education, conduct research critical to DOD national security needs, increase the number of graduates in the fields of science, technology, engineering and mathematics, and encourage research and educational collaboration with other institutions of higher education directed toward advancing the state of the art and increasing knowledge.

Mr. JOHNSON. What concrete steps are each of your organizations doing to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs)? Is there more that Congress can do to help expand efforts with the HBCU/MSIs?

Admiral KLUNDER. The Office of Naval Research (ONR) has several initiatives under way to strengthen our relationships with Historically Black Colleges and Universities and Minority Serving Institutions (HBCU/MSIs). Highlights include:

- Conducted the 2013 ONR Summer Faculty Fellowship program competition with increased outreach to HBCU/MI. Received 230 applications. Eighty-four applications were selected nationwide. Of the 84 applicants selected, 38 were from HBCU/MI's (45%).
- Convened a high-level review panel of seven reviewers for the Summer Faculty review process; four panelists were from the government scientific community, and three from academia. All were experts in their fields; two panel members were from HBCU/MSIs.
- Created the Future Scientist Summer Intern Program that will provide an opportunity for 40 HBCU/MI undergraduate students to conduct naval relevant research at a Navy laboratory or warfare center in 2014.
- Developed the initial steps to form a new partnership with the following HBCUs: Bowie State University, Howard University, Morgan State University, and the District of Columbia University. The purpose of the partnership is to investigate research areas of importance to the Department of the Navy (DON).
- Increased by 15% the number of HBCU/MI undergraduate and graduate interns who will be conducting naval relevant research at Naval Research Laboratory (NRL) in FY14.
- Developed strategies to identify and engage second tier emerging HBCU/MI research programs, providing them the opportunity to compete for naval relevant research opportunities.
- Drafted the preliminary language for a HBCU/MI Broad Agency Announcement (BAA). This BAA will provide a specific vehicle for HBCU/MI institutions to submit proposals and white papers for future research opportunities relevant to the DON.
- Establishing at the University of Texas—El Paso (UTEP)—a minority serving institution—a Master's of Science Degree in Cyber Security. This UTEP program is modeled after the highly successful Systems Engineering Master's degree program that was developed for the Naval Sea Systems Command at Tuskegee University, an HBCU.

We appreciate the funding that Congress has provided the DON to reach out to the HBCU/MI community. We believe that the steps we have taken over the last year (see above) have dramatically improved the effectiveness of that outreach.

Mr. JOHNSON. What concrete steps are each of your organizations doing to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs)? Is there more that Congress can do to help expand efforts with the HBCU/MSIs?

Dr. WALKER. The Air Force remains committed to strengthening HBCU/MSIs. Each technical directorate of the Air Force Research Laboratory (AFRL) is tasked to identify at least one HBCU/MSI as a targeted recruiting opportunity based on needed technical competencies, and identify a relationship manager for each school/department identified. The relationship managers ensure regular contact with potential recruits, create opportunities for exchanges and student exposure to AFRL, and develop contacts with the targeted university (that includes faculty, students, and alumni) within the directorate or across AFRL.

AFRL ensures that HBCU/MSIs are aware of various funding opportunities available throughout the year. In FY12, the Air Force Office of Scientific Research (AFOSR), a component of AFRL, funded 22 research and instrumentation grants at 18 HBCU/MSIs. AFOSR funding is above and beyond OSD's HBCU/MSI program. The principal investigators (PIs) at institutions that receive grants are steadily building research expertise and many are seen as leaders in their research areas.

The Air Force continues to place strong emphasis on PI development by selecting HBCU/MSI faculty to serve on scholarship, fellowship, and research review panels, and encouraging HBCU/MSI students to apply for STEM scholarship, fellowship, and internship programs offered by DOD. Additionally, AFOSR has a full-time HBCU/MSI program coordinator focused on growing relationships with HBCU/MSIs and the AFOSR STEM program manager is a member of advisory councils for HBCU/MSIs that help to foster relationships with institutions.

Mr. JOHNSON. What concrete steps are each of your organizations doing to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs)? Is there more that Congress can do to help expand efforts with the HBCU/MSIs?

Dr. PRABHAKAR. The Defense Advanced Research Projects Agency (DARPA) has implemented the following steps to reinvigorate the DOD relationship with the historically black colleges and universities and minority serving institutions (HBCU/MSIs):

- DARPA is able to monitor HBCU/MSI success rates in response to its Broad Agency Announcements (BAAs) and other solicitations through information readily available from the Federal Procurement Data System-Next Generation.
- DARPA includes HBCU/MSI opportunities in our BAAs.
- DARPA is speaking honestly and directly with potential university partners to encourage researchers to renew their commitment to working on critical Defense solutions. To achieve this goal, DARPA is making it easier for university leaders to engage by clearing obstacles and encouraging our nation's best and brightest to serve in Government. Individuals possessing the required skill and talent to serve as program managers could serve via the Intergovernmental Personnel Act or through other hiring mechanisms available to DARPA.
- A DARPA Program Manager is on the Science, Technology, Engineering, and Mathematics (STEM)-focused panel for the White House Office of Science and Technology Policy, and works closely with the U.S. Department of Education. Both organizations support initiatives that solicit representation from under-represented groups, including faculty and students of HBCUs/MSIs.
- DARPA removed barriers to HBCU/MSI participation in its Young Faculty Award program. Previously, participation was limited to untenured Assistant or Associate Professors within five years of appointment to a tenure-track position at a U.S. institution of higher education. The solicitation language was revised and the portion in quotes was added to give HBCU/MSIs the opportunity to participate: Participation is limited to untenured Assistant or Associate Professors within five years of appointment to a tenure-track position at a U.S. institution of higher education "... or equivalent at a non-profit science and technology research institution." The solicitation also specifically stated: "Historically Black Colleges and Universities (HBCU's) and Minority Institutions (MI's) are encouraged to submit proposals." DARPA determined allowing this participation is in line with the well-established National Science Foundation and other federal guidelines listed below.
 - 1) The employing organization does not offer tenure track appointments.
 - 2) The appointment is a continuing appointment (soft-money appointments and/or visiting appointments do not apply).

In these cases, the organization must make the determination that the appointee meets these guidelines prior to proposal submission, and must provide verification in lieu of a tenure track appointment date.

DARPA is not currently providing funding to any HBCUs for other than acquisition and grant and agreement activities, but will fund HBCUs consistent with 10 U.S.C. 2362. DARPA is not currently participating in any HBCU/MSI focused outreach events this time, but will continue to seek out opportunities to do so.

QUESTIONS SUBMITTED BY MR. CARSON

Mr. CARSON. I have heard from many businesses in my district—both large and small—that have developed innovative technologies under DOD contracts but have not reached the procurement stage. Some of have been fortunate enough to find private sector applications for these technologies. But others have seen their R&D programs come to an end and their technologies sit unused. I am interested in knowing what steps each of you take to ensure that these technologies—which are paid for by American taxpayers—are put to good use? Are there efforts to catalog this research and communicate it to other services, agencies and contractors to ensure that the same research is not repeated unnecessarily on future programs?

Mr. SHAFFER. [The information was not available at the time of printing.]

Mr. CARSON. I have heard from many businesses in my district—both large and small—that have developed innovative technologies under DOD contracts but have not reached the procurement stage. Some of have been fortunate enough to find private sector applications for these technologies. But others have seen their R&D programs come to an end and their technologies sit unused. I am interested in knowing

what steps each of you take to ensure that these technologies—which are paid for by American taxpayers—are put to good use? Are there efforts to catalog this research and communicate it to other services, agencies, and contractors to ensure that the same research is not repeated unnecessarily on future programs?

Ms. MILLER. The Defense Technical Information Center (DTIC) is the hub of Department of Defense (DOD) Scientific and Technical information and provides the venue for information exchange between the Services to insure that the same research is not repeated. The Army participates in DTIC's Scientific and Technical Information Program (STIP), an online database of DOD research efforts. STIP recognizes the impact and efficient sharing of releasable information within agencies and activities of the DOD and outside the Army; these agencies and activities include other Federal, State, university, not-for-profit, and commercial institutes. Additionally, since 2012, the Army has joined with the other services to support the Defense Innovation Marketplace (<http://www.defenseinnovationmarketplace.mil>) by providing key research, development and acquisition information in one easy to find location. The Marketplace is a portal for companies, large and small, to securely share their Independent Research & Development (R&D) projects to increase government visibility of their technology. The project database is growing and holds more than 6,000 industry R&D projects, allowing department Science and Technology (S&T) program managers and acquisition executives to learn about industry technology and then fully leverage it for current or future programs.

The Department has several mechanisms to ensure S&T investments are coordinated with other Services and agencies, to ensure that the same research is not repeated unnecessarily on future programs, including monthly meetings of the Science and Technology Executive Committee, comprised of the Service S&T Executives and the Deputy Assistant Secretary of Defense (Research), and weekly meetings of the Deputies to the Service S&T executives. There are 17 Communities of Interest which are informal organizations to provide a forum for intra-Service and Component coordination and information exchanges in specific S&T topic areas primarily at the laboratory and research center level. Finally, there are seven Priority Steering Committees which develop integrated S&T investment strategies and roadmaps in capability areas of cross Service importance.

Mr. CARSON. I have heard from many businesses in my district—both large and small—that have developed innovative technologies under DOD contracts but have not reached the procurement stage. Some of have been fortunate enough to find private sector applications for these technologies. But others have seen their R&D programs come to an end and their technologies sit unused. I am interested in knowing what steps each of you take to ensure that these technologies—which are paid for by American taxpayers—are put to good use? Are there efforts to catalog this research and communicate it to other services, agencies, and contractors to ensure that the same research is not repeated unnecessarily on future programs?

Admiral KLUNDER. There are several aspects to answering this question. First, the Office of Naval Research is very proactive in working to facilitate transition of technology into further development and commercialization. For small businesses, we have established a Transition Assistance Program that works with them to develop relationships with potential customers, including Program Managers and prime contractors. Experience with the TAP has shown nearly a doubling in the likelihood of obtaining a Phase III (commercialization) contract for the Phase II products of the Small Business Innovation Research program. And, for the full range of businesses that participate in our Future Naval Capabilities program as an example, we engage directly with resource sponsors and transition partners (primarily Program Executive Officers/Program Managers) to document and sustain their commitment to transition the products. This has led to a healthy success rate in transitioning the products into acquisition programs and to the Fleet/Marine Forces.

Second, even when the products do not directly translate into procurements, they benefit the S&T and acquisition communities in a number of ways. Often, they lead to follow on research efforts, which build upon what was achieved and any lessons learned. They also aid in “setting the bar” for what capabilities can be achieved, reducing acquisition program risk, and establishing expectations for performance and price.

Finally, documentation of the results of the effort (published findings, interim and final reports, etc.) are indeed catalogued by the Defense Technical Information Center (DTIC), which serves as a repository for that information. The DTIC database is accessible by Government and industry researchers, who can use that information in developing new research thrusts by building upon what has already been done and avoiding unnecessary duplication of effort.

Mr. CARSON. As you may know, Crane Naval Surface Warfare Center is located just south of my district in Southern Indiana. This facility is absolutely critical to our State and contributes to a strong research and development and supplier industrial base in my district. Can you discuss the importance of Crane to the overall mission of the Navy and the role you anticipate that it and other surface warfare centers will play as we retool for future missions?

Admiral KLUNDER. The Naval Sea Systems Command Warfare Center Enterprise is comprised of the Naval Surface Warfare Center (NSWC) and the Naval Undersea Warfare Center (NUWC). With eight Surface Warfare and two Undersea Warfare sites across the United States, the Warfare Centers supply the technical operations, people, technology, engineering services and products needed to equip and support the fleet and meet the warfighters' needs. The Warfare Centers are the Navy's principal research, development, test and evaluation (RDT&E) assessment activity for surface ship and submarine systems and subsystems. In addition, the Warfare Centers provide depot maintenance and in-service engineering support to ensure the systems fielded today perform consistently and reliably in the future.

The Naval Surface Warfare Center (NSWC) Crane Division is one of eight commands within NSWC. The mission of NSWC Crane is to provide acquisition engineering, in-service engineering and technical support for sensors, electronics, electronic warfare and special warfare weapons. NSWC Crane also works to apply component and system-level product and industrial engineering to surface sensors, strategic systems, special warfare devices, and electronic warfare and information operations systems. Crane has focused particularly on three mission areas where they can best support the Warfighter.

The Special Missions Center provides elite Warfighters with a distinct advantage in the rapidly changing combat environment. Areas of support include Special Operations, Irregular Warfare and Riverine Operations, among others. With more than one million square feet of offices and laboratories, the Special Missions Center's focus is on sensors and communications, mobility and maneuverability, special munitions and weapons and technical training. The Center is a go-to source for the Warfighter who requires expertly delivered solutions that ensure safe and effective missions. The Strategic Missions Center is a trusted source for the critical electronics and sensors required for global deterrence and ballistic missile defense. Through its recognized leadership, preeminent facilities and experienced personnel, the Center is dedicated to developing, deploying and sustaining the technologies that ensure weapons systems are fully reliable and always available to defend the homeland. Strategic Missions resources deliver innovative technical solutions encompassing the full range of military activities to alter an adversary's will and ability to attack the U.S. and its interests. Offering 50 years of naval strategic mission success, the Center is dedicated to delivering the best technical solutions in Threat Detection, Integrated Missile Defense and Global Strike. The Electronic Warfare/Information Operations (EW/IO) Center provides a critical mass of co-located leadership to offer applied science solutions across Air, Ground and Maritime Domains. Its experts afford Electronic Attack, Electronic Protection and Electronic Support capabilities to the Warfighter to ensure safe and effective missions. An EW Center of Excellence, the EW/IO Center is the largest multi-service facility within the Department of Defense for EW, EW Sensors and electronics.

Mr. CARSON. I have heard from many businesses in my district—both large and small—that have developed innovative technologies under DOD contracts but have not reached the procurement stage. Some of have been fortunate enough to find private sector applications for these technologies. But others have seen their R&D programs come to an end and their technologies sit unused. I am interested in knowing what steps each of you take to ensure that these technologies—which are paid for by American taxpayers—are put to good use? Are there efforts to catalog this research and communicate it to other services, agencies and contractors to ensure that the same research is not repeated unnecessarily on future programs?

Dr. WALKER. The Air Force Research Laboratory (AFRL) makes every effort to ensure developed technologies are put to good use. Competing technology approaches are often funded to reduce high technical risk. Though two or more technologies may prove successful, it is generally most cost effective to select only the one best suited for the system to be developed. Occasionally, user requirements are changed during science and technology development due to changing threat environment or defense strategy. In other cases, another competing technology may prove more successful when demonstrated. In a few cases, there may be legal or data rights issues that prevent a planned transition.

The Air Force requires that AFRL research summaries be developed and submitted for every unit of research work done at the laboratory. The data is collected

by the Defense Technical Information Center (DTIC) and is used to populate an extensive database. All researchers are required to query this database before starting any new efforts. Researchers are also required to submit a final report to DTIC at the conclusion of their efforts.

Additionally, the DOD has opened a new DTIC website called the Defense Innovation Marketplace. This site is being used to drive additional collaboration and information sharing between all research arms of the DOD and defense industry—large and small.

For Small Business Innovation Research (SBIR) contracts, the Air Force uses multiple approaches to advertise the products of those efforts to system developers and, in many cases, facilitate bringing the prospective partners together. The Air Force is also making full use of the Air Force Commercialization Readiness Program to assist with the transition of Phase II SBIR products to using Major Commands.

Mr. CARSON. I have heard from many businesses in my district—both large and small—that have developed innovative technologies under DOD contracts but have not reached the procurement stage. Some of have been fortunate enough to find private sector applications for these technologies. But others have seen their R&D programs come to an end and their technologies sit unused. I am interested in knowing what steps each of you take to ensure that these technologies—which are paid for by American taxpayers—are put to good use? Are there efforts to catalog this research and communicate it to other services, agencies and contractors to ensure that the same research is not repeated unnecessarily on future programs?

Dr. PRABHAKAR. [The information was not available at the time of printing.]

QUESTIONS SUBMITTED BY MR. MAFFEI

Mr. MAFFEI. Considering and expanded strategic Department of Defense vision for Asia and Africa, we note with great interest and appreciation the emerging military medical research in the areas of global health, bio-defense, bacterial health, combating bacterial infections in fixed and mobile military medical facilities and bacterial translational science. Please share in detail with the Committee, what research and development is military medicine exploring regarding molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections in order to develop treatments and therapies independent of antibiotics?

Mr. SHAFFER. The following research and development efforts regarding molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections are being supported by the DOD.

Funding Agent: Military Infectious Disease Research Program (US Army)

Performer: University of Idaho

This research effort investigates how bacterial metabolism controls persister formation in biofilms. Bacterial persistence is a phenomenon in which a small fraction of a bacterial population (.0001 to 1%) enters dormancy in otherwise growth-promoting conditions to survive future stress (e.g., antibiotic treatment). These survivors are responsible for the relapse of biofilm infections, and thus a greater understanding of their formation will lead to more effective therapies against biofilm-utilizing pathogens, such as *Pseudomonas aeruginosa*, *Escherichia coli*, and *Acinetobacter baumannii*. Researchers have discovered that diauxic carbon shifts stimulate the generation of persisters in planktonic cultures, and believe this to be a general phenomenon in response to metabolite fluctuations. Biofilms are highly heterogeneous communities in which the microenvironment of encased bacteria changes considerably as the film matures. The hypothesis is that metabolic control of persister formation is a dominant mode of persister generation in biofilms, and that a mechanistic understanding of this phenomenon will lead to novel treatment strategies. This effort will elucidate how metabolism controls persister formation in biofilms, and identify targets of therapeutic interest for the reduction of relapse infections from biofilms in combat-wounded personnel. This project aligns with the focus area on identification and characterization of microbial virulence factors and other potential therapeutic targets of metabolic or signaling pathways associated with wound infection and/or biofilm formation, maintenance, and propagation processes.

Funding Agent: Military Infectious Disease Research Program (US Army)

Performer: University of New York, Binghamton

The research project evaluates the role of bacterial super-antigen (Sag) proteins in activating systems contributing to biofilm formation and resistance. Biofilms are extremely difficult to eradicate by conventional antimicrobial treatments and are

considered the root of many persistent and chronic bacterial infections. For a long time, the nature of biofilm resistance was deemed to be multifactorial. However, recent evidence suggests that in *P. aeruginosa*, biofilm resistance is regulated by SAg proteins. SAg protein is a novel *P. aeruginosa* regulator that not only plays a role in initial colonization of surfaces, but also in the maintenance of established biofilms and the development of biofilm resistance. SAg protein was found to control the phosphorylation status of biofilm signaling protein (BfiS), a regulatory protein previously found to be essential for biofilm formation. While a BfiS mutant only demonstrated a defect in biofilm formation but not resistance, inactivation of the upstream SAg protein impaired biofilm formation and made *P. aeruginosa* cells more susceptible to antimicrobial treatments. Based on these preliminary findings, the hypothesis is that SAg protein transduces growth mode-specific signals to other regulators via phospho-relay events to activate multiple systems involved in the architectural formation of biofilms and the development of biofilm resistance. The goal of this project is to characterize the SAg protein-dependent signaling mechanism controlling the transition of *P. aeruginosa* to the surface-associated lifestyle, and the formation of highly resistant biofilms.

Funding Agent: Office of Naval Research (ONR)

Performer: The Scripps Research Institute

Lateral gene transfer is one of the major routes by which bacteria evolve resistance to antibiotics. The primary aim of this research is to identify lead compounds that inhibit lateral gene transfer and virulence, while also killing the bacteria by inhibiting antibiotic resistance mechanisms. This work targeted the Bacterial Type I Signal Peptidase (SPase I) since it is required to cleave mature proteins from the signal peptide that targets them for translocation across the cytoplasmic membrane. This process is required for bacterial cell viability and occurs on the outer leaflet of the cytoplasmic membrane, making it an attractive target for an antibiotic. However, because secreted proteins are required for lateral gene transfer and virulence, SPase I inhibitors should also inhibit gene transfer and virulence. To date, this work has identified the arylomycin class of natural product antibiotics as inhibitors of SPase I and has demonstrated that arylomycin inhibits lateral gene transfer.

Funding Agent: Office of Naval Research (ONR)

Performer: University of Wisconsin

Many species of bacteria use a chemical signaling process (i.e., quorum sensing) to sense a quorum and coordinate secretion of virulence factors as a response. Quorum sensing also controls biofilm formation as well as other processes. The primary goal of this work is to probe quorum sensing as a new target for the treatment of bacterial infection and the eradication of biofilms. Since dihydrofolate reductase and dihydropteroate synthetase play a central role in the synthesis of nucleic acid precursors, the essential building blocks of DNA and RNA, inhibition of these enzymes should limit the growth and proliferation of bacterial cells. This work seeks to identify inhibitors of dihydrofolate reductase. A second objective of this work is to develop polymeric materials for the surface-mediated release of quorum-sensing modulators. Two approaches are being taken for the surface mediated release of quorum sensing inhibitors: (1) Encapsulation / release from thin films of a bulk biocompatible, biodegradable polymer incorporating inhibitors of Gram-negative quorum sensing (degradation of the polymer releases the material), and (2) Loading/release from nanostructured 'polymer multilayers.' To date, biocompatible, biodegradable, bulk polymeric films incorporating inhibitors of Gram-negative quorum sensing on planar surfaces have been shown to (1) permit controlled release of quorum sensing inhibitors in biologically relevant media from hours to days to months, and (2) inhibit (90%) *Pseudomonas aeruginosa* film formation over 24–48 hours. ONR has funded highly successful research in the recent past that identified several promising inhibitors of a pro-mutagenic protein involved in induced mutagenesis, which was shown to play a key role in the evolution of resistance to the synthetic antibiotic ciprofloxacin. Those pro-mutagenic protein inhibitors were transferred to a commercial biopharmaceutical company in 2005 based entirely on results generated under Office of Naval Research funding.

Mr. MAFFEI. Considering and expanded strategic Department of Defense vision for Asia and Africa, we note with great interest and appreciation the emerging military medical research in the areas of global health, bio-defense, bacterial health, combating bacterial infections in fixed and mobile military medical facilities and bacterial translational science. Please share in detail with the Committee, what research and development is military medicine exploring regarding molecular road-blocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections in order to develop treatments and therapies independent of antibiotics?

Ms. MILLER. The Wound Infection Department of the Walter Reed Army Institute of Research (WRAIR) has a Cooperative Research and Development Agreement (CRADA) with the State University of New York, College of Environmental Science and Forestry (SUNY-ESF), Dr. Christopher Nomura, to explore the development of molecular roadblocks for an enzyme partially responsible for replicating a bacterial ribonucleic acid known as rpoN. This collaborative research seeks to investigate how rpoN regulates protein production in *Acinetobacter baumannii* and *Pseudomonas aeruginosa*, two life threatening wound pathogens frequently associated with multidrug resistant infections in wounded military personnel. The ultimate goal of the work is to determine whether rpoN could be blocked by drugs and if so, foster development of new anti-bacterial drugs that inhibit this enzyme. This effort was established this year as a small initial effort geared at obtaining preliminary data to support larger collaborative efforts in subsequent years.

Mr. MAFFEI. Considering and expanded strategic Department of Defense vision for Asia and Africa, we note with great interest and appreciation the emerging military medical research in the areas of global health, bio-defense, bacterial health, combating bacterial infections in fixed and mobile military medical facilities and bacterial translational science. Please share in detail with the Committee, what research and development is military medicine exploring regarding molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections in order to develop treatments and therapies independent of antibiotics?

Admiral KLUNDER. The Navy Medicine Medical Research and Development laboratories and clinical centers, including the Naval Medical Research Center and its seven subordinate labs, are not engaged in any research or development activities exploring molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections. Specifically, there is no such research being conducted with a goal to develop treatments and therapies for infections with such organisms, independent of antibiotics.

Mr. MAFFEI. Considering and expanded strategic Department of Defense vision for Asia and Africa, we note with great interest and appreciation the emerging military medical research in the areas of global health, bio-defense, bacterial health, combating bacterial infections in fixed and mobile military medical facilities and bacterial translational science. Please share in detail with the Committee, what research and development is military medicine exploring regarding molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections in order to develop treatments and therapies independent of antibiotics?

Dr. WALKER. The Air Force respectfully defers this question to the Office of the Secretary of Defense, Health Affairs (Defense Health Program).

Mr. MAFFEI. Considering and expanded strategic Department of Defense vision for Asia and Africa, we note with great interest and appreciation the emerging military medical research in the areas of global health, bio-defense, bacterial health, combating bacterial infections in fixed and mobile military medical facilities and bacterial translational science. Please share in detail with the Committee, what research and development is military medicine exploring regarding molecular roadblocks and protein switches to regulate gene expression in non-Staphylococcus bacterial infections in order to develop treatments and therapies independent of antibiotics?

Dr. PRABHAKAR. The DARPA Defense Sciences Office currently supports significant research efforts to develop treatments and therapies independent of antibiotics. The Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) Program is exploring several approaches that target genetic constructs in order to tune the immune system response to infections and toxins. The following academic institutions are pursuing a variety of genetic engineering strategies:

- Cornell University: Using synthetic biology to develop combinatorial genetic switches for high resolution monitoring of *Mycobacterium tuberculosis* infection and drug screening in order to develop targeted combination therapies.
- Massachusetts Institute of Technology: Engineering ribonucleic acid (RNA)-based circuits for controlling timing and level of expression of antibodies and vaccines produced from RNA vectors.
- Stanford University: Developing RNA-based switches that can turn expression of antibodies or vaccines from RNA vectors 'on' or 'off' in response to delivery of a small molecule drug.

- Harvard University: Using directed evolution to rapidly generate proteases and antibody-like proteins with the ability to therapeutically cleave or target any protein of interest with a high degree of specificity.
- California Institute of Technology: Preventing spread of vector-borne diseases by engineering reversible genetic methods to introduce genes that mediate disease refractoriness to high frequency in wild populations.

Additionally, a newer effort will use genetic constructs to express protective antibodies in the body. This platform technology can be used as a prophylactic against multiple types of infections or toxins. Companies and academic institutions are being supported to target different approaches to antibody expression:

- Pfizer, Novartis, CureVac, Moderna, Ragon Institute: Developing RNA constructs that will express protective antibodies in the body. Pfizer is developing constructs that will protect against Burkholderia infection. CureVac is developing RNA constructs that will express antibodies to protect against botulinum toxin.
- University of Pennsylvania and Ichor: Developing DNA constructs that will express protective antibodies in the body.
- University of Pennsylvania: Developing adenoviral constructs that will express protective antibodies in the body.
- University of Massachusetts: Identifying antibodies that are protective against enterotoxigenic escherichia coli (ETEC).

Finally, three companies are supported by Small Business Innovation Research (SBIR) program funding to discover new methods to treat resistant or virulent bacteria. These efforts directly target drug-resistant or toxin-encoding plasmids, while protecting the general microbiome from harm:

- Agave BioSystems: Developing antisense therapeutics to inhibit drug resistance gene transfer in both gram-positive and gram-negative bacteria.
- UES, Inc.: Exploiting group II introns (novel class of catalytic RNA) to selectively inactivate genes critical for plasmid replication and maintenance and/or activate a toxic payload on inserting into plasmid specific sequences. The ability to prevent plasmid replication will offer a method to control the spread of multi-drug resistance.
- Ginkgo BioWorks: Controlling antibiotic resistance by vaccinating bacterial populations using the Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR)/CRISPR-associated (Cas) bacterial immune system (stored deoxyribonucleic acid (DNA) fragments that target specific foreign DNA sequences; Cas genes process the CRISPR RNA to identify and degrade target DNA).

QUESTIONS SUBMITTED BY MR. LANGEVIN

Mr. LANGEVIN. Certainly we are not the only nation that is concerned about the advanced A2/AD threats. In your views, are we doing enough coordination with our allies on research and development of directed energy systems?

Mr. SHAFFER. Yes, I am confident that the Department is engaged with our allies in research on directed energy systems. The Department has been coordinating with our allies on directed energy (at both unclassified and classified levels) for well over two decades. Recently, coordination has been expanded, primarily because of advancements in High Energy (Electric) Lasers and Radio-Frequency Weapons science and technology. In addition, the increasingly constrained fiscal environment provides strong impetus to coordinate with allies who are able to advance directed energy technology. The mechanisms used for this coordination are: (1) bilateral agreements; (2) NATO-Research and Technology (RTO) System Concept & Integration (SCI) Panel work; and (3) an Action Group under The Technology Cooperation Program (TTCP). In fact, the Science and Technology Executives of the United States, United Kingdom, Canada, Australia, and New Zealand, established this last group in the fall of 2012. The nature of the coordination may change in scope, as technology matures and/or budgets change, but the personnel contacts are in place, and they are actively engaged in exploring avenues for further cooperation.

Mr. LANGEVIN. How concerned are you about the DOD's STEM education pipeline? In your views, is DOD doing enough to nurture the next generation of STEM professionals?

Mr. SHAFFER. [The information was not available at the time of printing.]

Mr. LANGEVIN. Relating to the health of the DOD Labs and R&D Workforce, how would you characterize the health of these areas, particularly as we factor in the effects of sequestration?

Mr. SHAFFER and Dr. PRABHAKAR. While the Department currently has both good laboratories and a strong R&D workforce, I do have some concerns about the future health of the labs and most importantly, the health of the lab R&D workforce. As will be seen in the DOD Human Capital Workforce Strategic Plan, the overall workforce continues to age and impending retirements of key personnel remains a concern. We surveyed each of our labs and found lab directors are concerned about the potential loss of leading scientists and engineers in areas of critical need to their labs. Normally loss of senior or essential S&Es is troublesome but given the authorities granted to the Science and Technology Reinvention Laboratories (STRs), directors can plan for the replacement of retirees or quickly hire to replace an unexpected loss. However, these are not normal times. With the prolonged pay freeze, travel restrictions, limitations on conference attendance, and potential reductions in force, the retention and hiring of S&Es is growing more difficult. As the national economy improves, defense labs may not be able to compete for top talent nor will they be able to retain their best S&Es.

Our laboratories represent a unique personnel element of the Department. To ensure they can stay on the leading edge of science, technology and engineering developments, they depend on the ability to travel to professional meetings, maintain their labs with essential equipment, have access to technical journals and other items considered essential in the routine performance of technical work. Many of these activities have simply been lost or are no longer available because of the restricted budgets. These facts along with those stated above could result in an overall decline in the technical health of our labs.

Mr. LANGEVIN. Relating to the health of the DOD Labs and R&D Workforce, how would you characterize the health of these areas, particularly as we factor in the effects of sequestration?

Ms. MILLER. The Army laboratories are, on average, 50 years old with minor facility functional/configuration deficiencies that have minimal impact on the capability to support the organizations' required missions. Sequestration will have a direct impact on the laboratories as the amount of sustainment, restoration, and modernization funding available to the laboratories is reduced.

The average age of the Research and Development workforce is 45 years old. Periods of budget uncertainty to include sequestration are having a negative impact on our ability to recruit and retain the best scientists and engineers. Compounding this uncertainty with a reduction in the ability to travel and restrictions on conference attendance has been especially harmful to the professional development of younger scientists and engineers and is already resulting in their departure from our Government labs.

Mr. LANGEVIN. Certainly we are not the only nation that is concerned about the advanced A2/AD threats. In your views, are we doing enough coordination with our allies on research and development of directed energy systems?

Ms. MILLER. Yes, the Army is working with many of our allies on research and technology development of directed energy systems. The Army has periodic technical discussions and interactions on directed energy topics of mutual interest with the United Kingdom, Canada and Australia in coordination with the U.S. Navy, Air Force, and the Assistant Secretary of Defense for Research and Engineering High Energy Laser Joint Technology Office (HEL JTO). The Army is working with the North Atlantic Treaty Organization to define current, near term, and far term directed energy capabilities for High Power Microwaves (HPM) and Lasers as well as non-lethal capabilities for the dismounted soldier.

The Army has been working with Japan, Germany, and Israel in the High Energy Laser area and recently contributed to a HEL JTO-led assessment of Germany's thin disc laser technology. The Army is working with Japan and South Korea on non-nuclear electro-magnetic pulse technologies and components in support of explosive pulsed power HPM. The Army also is working with Sweden to investigate the susceptibility of counter-mine/counter-improvised explosive device systems to radio frequency and HPM waveforms.

Mr. LANGEVIN. As you know, this subcommittee has authorized several pieces legislation over the past 5 years intended to improve the health of the laboratories. Section 219 in the FY09 NDAA authorized the use of funds to support various local initiatives. We also reauthorized and raised the spending limits in the Laboratory Revitalization Demonstration Project (LRDP) which is intended to support minor milcon projects. Could you tell the committee how you use 219 and LRDP to improve the conditions of your labs. More importantly, please let us know where we might improve on those authorities.

Ms. MILLER. The expansion of the Section 219 authority that included minor military construction as one of the acceptable categories of use has allowed the labora-

tories to fund 27 projects related to their core competencies across six laboratories. These projects, using the LDRP authority, range from the construction of additional research space to building modifications made to address safety concerns. Full details on the Army's use of Section 219 funds are available in the annual Report to Congress, which was delivered to the Congressional Defense Committees by the Office of the Secretary of Defense on April 10, 2013.

At this time, no additional authorities are sought as the organizations continue to exercise the existing flexibilities authorized via Section 219. The Army looks forward to working with Congress to review any proposed changes to the Section 219 authorization.

Mr. LANGEVIN. How concerned are you about the DOD's STEM education pipeline? In your views, is DOD doing enough to nurture the next generation of STEM professionals?

Ms. MILLER. The Army is concerned with the growing demand on science, technology, engineering and mathematics (STEM) competencies, the global competitiveness for STEM talent, and the unbalanced representation of our nation's demographics in STEM fields. The Army is not only concerned with the percent of Army Science and Technology occupations requiring STEM skilled talent, but also with the workforce as a whole, which is dependent on STEM competencies that are in demand both within and outside traditional STEM occupations. The Army, through the Army Educational Outreach Program (AEOP), continues to address building the pipeline of STEM professionals by providing our future generation access to Army unique capabilities, which include our technical STEM professionals and research facilities. To effectively nurture the next generation of STEM professionals, the objective of AEOP is to develop a diverse, agile and highly competent STEM talent pool, representative of our nation's demographics, that supplies the Army and the broader Defense Industrial Base workforce initiatives.

Mr. LANGEVIN. Relating to the health of the DOD Labs and R&D Workforce, how would you characterize the health of these areas, particularly as we factor in the effects of sequestration?

Admiral KLUNDER. The DON has historically made deliberate and measured investments to ensure stability within the organic workforce to ensure continuity of technical capabilities. The DON has emphasized having our Laboratories and Warfare Centers actively engaged during the early development stage. Over the last year the DON has performed an extensive strategic review of our research, development, test, and evaluation (RDT&E) resources, including Laboratory and Warfare Center technical workforce and their critical infrastructure. This baseline of the 'as is' technical capabilities and capacities of our Laboratory and Warfare Center infrastructure will enable an integrated assessment of the RDT&E capabilities. We will use this assessment to prioritize our investments in this period of tightening budgets.

Mr. LANGEVIN. Certainly we are not the only nation that is concerned about the advanced A2/AD threats. In your views, are we doing enough coordination with our allies on research and development of directed energy systems?

Admiral KLUNDER. Yes, we are working with our allies on research and development of directed energy systems. The U.S. Navy coordinates their directed energy weapons science and technology research, as with many extracurricular initiatives, through the Navy International Programs Office (NIPO), as a part of the Office of Naval Research (ONR) Global outreach program. Separate meetings have been held in 2013 with representatives from the Ministry of Defense (MoD) offices from the United Kingdom, Australia, and Japan. While additional coordination is potentially possible, the limited requirements for other countries to address advanced A2/AD threats seen by U.S. Forces, and their relative immaturity of DE Technologies, suggests sufficient coordination is and shall occur within the ONR Global program in both the near term, and longer terms.

Mr. LANGEVIN. As you know, this subcommittee has authorized several pieces legislation over the past 5 years intended to improve the health of the laboratories. Section 219 in the FY09 NDAA authorized the use of funds to support various local initiatives. We also reauthorized and raised the spending limits in the Laboratory Revitalization Demonstration Project (LRDP) which is intended to support minor milcon projects. Could you tell the committee how you use 219 and LRDP to improve the conditions of your labs. More importantly, please let us know where we might improve on those authorities.

Admiral KLUNDER. Section 219 has allowed the Naval Laboratory and Warfare Centers to revitalize and refresh technical capabilities through hands-on basic and applied research initiatives, pre-milestone "A" technology transition and workforce development. Under workforce development it has allowed scientists and engineers

to pursue advanced degrees, certifications, mission critical training, and has allowed the Navy to recruit and retain top technical talent.

It has enabled our laboratory directors to focus technical resources on technology transition opportunities where a warfighter need has been identified. The DON is continuing to investigate the most effective way to use the minor military construction (MILCON) authority. Under workforce development many warfare centers pursue projects which group under an area entitled "strategic growth" which is adding new laboratory capabilities. In this area, projects are often reviewed with the Capital Improvement Proposals (CIP) to see how SEC 219 might complement the effort. For instance, SEC 219 funds the major equipment purchase and associated training while CIP funds the infrastructure and construction of the required spaces. Examples of growth areas and new labs funded in this manner include: labs devoted to scanning electron microscope, biaxial testing of composites, and noise measurements and Naval Power Avionics and Thermal (NPAT) Laboratory Development, Integration, Analysis and Testing. As the program continues to mature, we anticipate more opportunities to use this authority.

Over the last several years, the DON has been able to grow and mature the Section 219 program so that it has become a critical, reliable and discretionary source of investment in areas most critical to understand the technical dimensions of near, mid and far term military challenges. We want to thank you for extending the sunset clause until 2016 and encourage you to make this a permanent authorization.

Mr. LANGEVIN. How concerned are you about the DOD's STEM education pipeline? In your views, is DOD doing enough to nurture the next generation of STEM professionals?

Admiral KLUNDER. We are concerned about the DOD STEM education pipeline. The Department of the Navy (DON) is working in coordination with DOD and national initiatives in STEM. Our plan is to engage early and often, especially in areas where we project shortfalls and in communities that are underrepresented. The DON plans to continue its investment in a broad range of STEM education programs aimed at strengthening the DON's future S&T workforce. Engaging students across the education spectrum is critical to ensure that we have ample pipelines of future STEM talent. The majority of DON STEM investments are at the college through post-doctoral levels. Programs provide naval-relevant research and employment opportunities to students likely to pursue a career within the DON or DOD industry. Efforts include internships, scholarships and research fellowships often located at naval labs and warfare centers.

Mr. LANGEVIN. Relating to the health of the DOD Labs and R&D Workforce, how would you characterize the health of these areas, particularly as we factor in the effects of sequestration?

Dr. WALKER. The Air Force recognizes the importance of innovation and has therefore continued to invest in science and technology even during these times of budgetary constraints to ensure that the future balance of power remains in our favor. The health of the Air Force Research Laboratory (AFRL) infrastructure and scientist and engineer (S&E) workforce is good.

The laboratory infrastructure is a cornerstone for enabling the required research and development necessary to maintain U.S. technological superiority. The 2005 Base Realignment and Closure (BRAC) effort successfully completed in September 2011 and provided several new, state-of-the-art facilities within AFRL. The Air Force has also used the authorities granted by Section 219 of the Duncan Hunter National Defense Authorization Act for Fiscal Year (FY) 2009, as amended by Section 2801 of the National Defense Authorization Act for FY 2010, to fund upgrades to internal AFRL facilities. A recent analysis of AFRL infrastructure as directed by Senate Report 112-173 to accompany the National Defense Authorization Act for Fiscal Year 2013 concluded that 90 percent of AFRL-occupied assets are classified as at least "Good" or "Fair" according to DOD criteria. The Air Force continues to be vigilant and upgrades S&T infrastructure in a timely manner so that major research and programs are not put at risk due to aging facilities. Maintaining high-quality laboratory facilities is critical to remaining on the cutting edge of S&T and supporting the innovation necessary for the future. Having the most state-of-the-art laboratory facilities is futile without the right people to conduct the research inside the walls. The success of the Air Force S&T Program depends on an agile, capable workforce that leads cutting-edge research, explores emerging technology areas, and promotes innovation across government, industry and academia. The Air Force must attract, access and retain our nation's best and brightest, and equip them through education, training and experience. The Air Force continues to execute the Bright Horizons STEM workforce strategic roadmap published in 2011. This roadmap addresses the "people" dimension of delivering and operating required technology by

having the right STEM qualified people in the right place, at the right time, and with the right skills.

The total impact of sequestration in FY13 and beyond remains unclear for the Air Force S&T enterprise at this time; however, there are currently research efforts which are being delayed, re-scoped or terminated. The Air Force will continue to diligently monitor the health and status of the laboratory infrastructure and workforce and ensure the Air Force is poised to retain superiority in air, space and cyberspace.

Mr. LANGEVIN. Certainly we are not the only nation that is concerned about the advanced A2/AD threats. In your views, are we doing enough coordination with our allies on research and development of directed energy systems?

Dr. WALKER. Yes. The Air Force coordinates research with U.S. Allies in several areas of directed energy components such as fiber lasers and other types of solid state lasers. In fact, the Air Force relies on Allies for some of these unique components and materials. Due to classification restrictions, further detail on directed energy coordination cannot be provided in this response.

Mr. LANGEVIN. How concerned are you about the DOD's STEM education pipeline? In your views, is DOD doing enough to nurture the next generation of STEM professionals?

Dr. WALKER. Nurturing the next generation of STEM professionals is an Air Force, DOD and National concern. There is a worldwide competition for STEM talent. The Air Force recognizes it is critical for us get out into the local communities and encourage students to study math and science. The U.S. Air Force is the most technologically advanced air force in the world; therefore recruiting, retaining and developing a STEM workforce is a top priority. Innovative and technically-savvy Airmen are our most important asset.

To this end, the Air Force has successfully used tools such as the Science, Mathematics, and Research for Transformation (SMART) Scholarship Program. Over the past eight years, the Air Force has averaged providing 60 scholarships per year to scientists and engineers. After payback of the recipient's commitment, the Air Force has retained 88 percent of scholars in Air Force jobs. In addition, the Information Assurance Internship provided through authorities granted in Section 219 of the 2009 National Defense Authorization Act, annually funds 10 to 20 college juniors and seniors in STEM disciplines to study the science of information assurance and information warfare on Air Force problems.

The Air Force also continues to execute the Bright Horizons STEM workforce strategic roadmap published in 2011. This roadmap addresses the "people" dimension of delivering and operating required technology by having the right STEM qualified people in the right place, at the right time, and with the right skills.

Mr. LANGEVIN. Certainly we are not the only nation that is concerned about the advanced A2/AD threats. In your views, are we doing enough coordination with our allies on research and development of directed energy systems?

Dr. PRABHAKAR. Yes. DARPA, in concert with the Department of Defense, has been coordinating with our allies on Directed Energy (at both unclassified and classified levels) for well over two decades. Recently, coordination has been expanded primarily because of advancements in High Energy (Electric) Lasers and Radio-Frequency Weapons Science and Technology (S&T), and because of the constrained fiscal environment. The mechanisms used for this coordination are: (1) bilateral agreement; (2) NATO-Research and Technology (RTO) System Concept & Integration (SCI) Panel work; and (3) Action Group under The Technology Cooperation Program (TTCP). The nature of the coordination may change in scope, as technology matures and/or budgets and priorities change, but the personnel contacts are in place and actively engaged to accommodate change.

Mr. LANGEVIN. How concerned are you about the DOD's STEM education pipeline? In your views, is DOD doing enough to nurture the next generation of STEM professionals?

Dr. PRABHAKAR. [The information was not available at the time of printing.]